THE EXPLOSIVES ENGINEER

MARCH - AVRIL 1950

VOLUME 28 NUMBER 2

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Views and opinions expressed by the authors of articles in this publication are their own and they do not necessarily represent those of the publisher.

Copperhill, Tennessee, has long been noted as a producer of the metal from which it derived its name. When the Tennessee Copper Company started operations in this area at the turn of the century it began a research and conservation program that has produced outstanding results. Mining efficiency has increased, products have multiplied, and conservation of natural resources has provided recreational facilities for the employes.

John Dantzler tells of the history and operations of this company in his article starting on page 39.

* * *

Richard L. Bullock, head mine research engineer for St. Joseph Lead Company at Bonne Terre, Missouri, concludes his article, "Fundamental Research on Burn-Cut Drift Rounds," in this issue. The first installment of this treatise, which appeared in our January-February issue, met with acclaim, and several mining schools have requested copies of the issue for classroom use. Please turn to page 44.

* * *

Starting on page 50 is an interesting account of the United States Steel Company's coal-mining operations in Utah. This article, the last assignment given to Lewis Nordyke, was completed just before his sudden and untimely death. In the article, Mr. Nordyke captures the spirit and feeling of the area and weaves an interesting and instructive description of the vast operation. We'll miss his facile and lucid pen in future issues.

* * *

When the National Crushed Stone Association held its annual convention, one of the highlights of the event was the presentation of THE EXPLOSIVES ENGINEER plaque to the Kimballton Mine, Kimballton, Virginia, of the Standard Lime and Cement Company division, American-Marietta Company. This award was made for operating the greatest number of consecutive days without a disabling work injury.

For details of this safety program see page 59.

* * *

The Beavers, an organization of heavy-construction-industry operators, recently honored four men for their outstanding contribution to that industry. A report of this ceremony will be found on page 61.

* * *

The mining camps of the Old West were the scenes of many interesting and sometimes humorous tales. Charles F. Thomas, an old-timer and frequent contributor to our pages, has written several short stories describing happenings in the old diggin's. The first story, "The Luck of the Irish," appears on page 62. Other stories by Mr. Thomas will be presented as space permits.

* * *

ERRATUM: Despite the most careful reading by the author and the editors there was a mistake in the formula on page 17 in Richard L. Bullock's article, "Fundamental Research on Burn-Cut Drift Rounds," in our January-February, 1961, issue. The correct formula should be:

$$R = KD\sqrt{\frac{P_o}{S}}$$

EDITORIAL STAFF: JAMES J. O'NEILL, *Editor;* THOMAS E. MILLER, *Associate Editor;* GERTRUDE A. DONNELLY, *Associate Editor;* EDWARD L. GRANT, *Art Editor;* HOWARD B. DICKSON, *Production Manager;* A. J. ACKERMAN, *Advertising Manager;* MONTGOMERY R. BUDD, *Director.*

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VOL. 39 NO. 2 MARCH-APRIL, 1961 BPA

new

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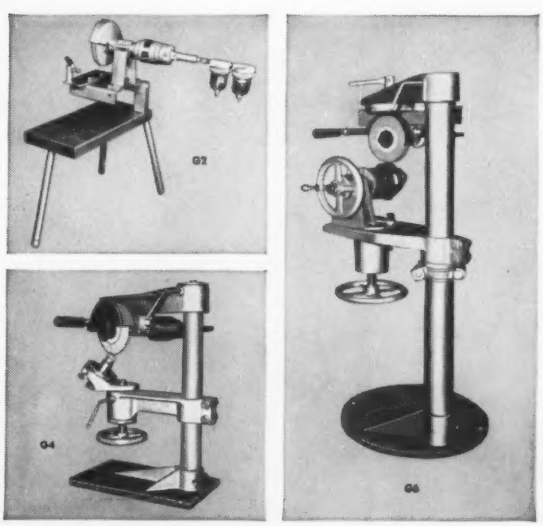

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Charles Donald Michaelson

GENERAL MANAGER, WESTERN MINING DIVISIONS

KENNECOTT COPPER CORPORATION

A Biography

CHARLES DONALD MICHAELSON, general manager of the Western Divisions of Kennecott Copper Corporation, is first and last a miner. With only one fall from grace during World War II, when he was manager of a gypsum plant in Midlands, California, he has clung to the mining profession as it took him from the Western United States to Chile, Bolivia, Mexico, Cuba, and back to the West again.

"Mike," as he is known to almost everyone, is a quick, agile, 6-ft. 2-in. executive who once played tackle for the Colorado School of Mines. He was born in Sycamore, De Kalb County, Illinois, of Norwegian, Irish, and German parentage, and received his early education in the public schools there. Mike took his first job at the age of 15 as an office boy and clerk for Trompeter & Company, paving contractors.

While in college Mike was captain of the football team, a member of Tau Beta Pi, Sigma Phi Epsilon, Sigma Gamma Epsilon, and Scabbard and Blade, was Commanding Colonel of the R.O.T.C. unit, and won the award for outstanding scholarship and athletic achievement.

Graduating from Colorado in the depths of the depression in 1932, he went to the old Smuggler-Union at Telluride, Colorado, as a miner, and gained experience as a timberman, leaser boss, shift boss, and night foreman. From there he went with Patino Mines at Siglo XX, Bolivia, as a section engineer, where he engaged in contract measurement, mine layout, and progress mapping. Siglo Veinte at that time was undergoing a rapid change from practically hand labor mining by the Bolivian Indians to mechanized mining. Much of his work from then on in Central and South America involved this change away from hand labor to mechanization.

Patino next sent him to Cia Minera y Agricola Oplaca, a subsidiary, as acting chief engineer for a year's experience, and then returned him to Siglo XX. He advanced to superintendent before he left the world's largest underground tin operation employing over 7,000 people.

In 1937 he took a vacation to come back home and marry Barbara Hemenway, whom he describes as "the girl next door."

With World War II threatening, he returned to the United States to become works manager of the U. S. Gypsum plant at Midlands, California. He stayed there three years until he went to the Nicaro Nickel Company in the Oriente Province, Cuba, as personnel manager. When that property closed down three years later, he joined the Fresnillo Company at Fresnillo, Zacatercas, Mexico, as superintendent of a large lead, zinc, silver, and gold mine. The job there, also, was the mechanization of underground mines, and the utilization of Mexican timber and fuel.

He left Mexico in 1948 to become manager of Cia Minera y Agricola Oplaca, which had just reopened after the first of the labor disorders which occurred in Bolivia. In the fall of that year he joined Braden Copper Company, Kennecott's subsidiary in Chile, as general superintendent of operations. Soon thereafter, he became general manager, director, and vice president of Braden, and at the end of 1955 came back to the States to become general manager, Western Mining Divisions of Kennecott, with headquarters in Salt Lake City.

Mike liked his years south of the border, and left with a deep, abiding affection for the South Americans. His work there has convinced him that the use of the modern management tools of industrial, public, and labor relations, engineering techniques, and research pay off for stockholders and employes.

One of Mike's proudest moments came in 1957 when his alma mater chose him as one of six distinguished Americans to receive an achievement award, the school's equivalent of an honorary degree.

He is an enthusiastic golfer and a member of the Salt Lake Country Club, the Alta Club, the Hidden Valley Country Club, the Salt Lake Rotary Club, the Mining Club of New York, the Union Club of Santiago, the Prince of Wales Country Club of Santiago, and the A.I.M.E. He is active in community welfare, school, and education affairs. He and Mrs. Michaelson live at 5186 Holladay Boulevard, Salt Lake City.

CHARLES D. MICHAELSON

Editorial

Iron Mining Fights for Its Life

The iron mining industry in Minnesota is making a concerted effort to acquaint the people of that state with the condition which the industry faces as it labors under the burden of state taxes. By speeches, articles, news, and prepared papers, the industry is setting forth the dire necessity of tax revision if iron mining is to survive.

One of the best presentations is that made by Herbert C. Jackson, vice president of Pickands, Mather, before the annual mining symposium at Duluth last January.

"The Minnesota tax system imposes on the iron ore mining industry, other than taconite, inequity multiplied by inequity, compounded by unfairness, multiplied by penalties, and so on for at least six additional or compounding statutory and administrative discriminatory tax features, as compared to other industry in the state," he says.

The total annual tax burden on iron ore other than taconite has increased from 33 cents a ton in 1945 to $1.48 a ton in 1959. The situation, already serious, is becoming more precarious as the result of the inroads of Canadian and other foreign ores, which can meet the wishes of the mills for ore of 64% iron and 9% silica. The competitive picture for Minnesota ore, except for taconite, which has received special tax consideration to stimulate its development, is now such that the very existence of the other iron mines on the range is threatened.

The only solution, he says, is the painful one that the people of the iron range communities, and other industries and commercial establishments, will have to either drastically reduce municipal expenditures, or increase their share of the tax load or, more likely, do both.

Some of the figures he cites are startling. For instance, the assessed value of a house, whose actual value is $10,000, is $250, while the assessed value of a mine property, of the same actual value, is $5,000, twenty times as much. He points out one community, Mountain Iron where, because the amount of taxable property was reduced by mine exhaustion, the mill rate was raised until in 1957 it reached 749 mills; in other words, in Mountain Iron in 1957 the tax payable was 75% of the assessed value, "the highest mill rate of any taxing district in the history of the United States."

His presentation ends with a stirring call for legislative action. "If Minnesota really wants a healthy and expanding mining industry—if it wants an industry which will not bear the first brunt of every reduction in iron ore demands—if it wants an iron ore industry which will employ more, rather than fewer and fewer men—then that desire must be shown by changes in the Minnesota tax picture. . . . If not, this would truly be to the iron-ore industry in Minnesota 'Death by Taxes.'"

Not only for the sake of the Minnesota iron mines, but for the mining and petroleum industry throughout the country, we hope that a solution for this problem can be reached soon. "The power to tax is the power to destroy" applies equally well to any of the nation's natural resources, and a crushing tax burden can put our extractive industries at such a disadvantage that they cannot hope to compete in world markets.

Recreation or Mining?

The issue appears to be squarely drawn between the mining industry in the United States, as represented by the American Mining Congress, and the advocates of a wilderness-preservation system. As so often happens, much can be said on both sides of this question. We can see some merit in the arguments of the outdoor enthusiasts who want to preserve some of our wilderness areas unsullied and untouched as they have stood for centuries against the inroads of an advancing civilization. For these outdoorsmen who want to really "rough it" in the wilds miles away from the nearest filling station or roadside stand, probably only some such wilderness bill is going to preserve these areas.

On the other hand, we think the American Mining Congress, in a recent statement, has some cogent arguments. It says the wilderness bills proposed would prohibit the construction of permanent roads, and bar the use of automobiles and motor boats. They would prohibit, with certain limited exceptions, any mining or productive activities, even dude ranching, within the Wilderness System.

"Who, then, would have greater opportunities for outdoor recreation?" the Mining Congress asks. "Certainly not the average American family, which relies on its car to get to and from recreation areas. It seems obvious that only the relatively few people with plenty of time and money to hire guides and hike, ride horseback, or canoe could enjoy the wilderness."

Furthermore, as the Mining Congress points out, mining often has increased the accessibility of recreation areas and national monuments through the roads built to reach mineral deposits.

Meanwhile, Senate Bill 174 would prohibit all these things. The only exception is that the President may, within a specific area, authorize prospecting, mining, oil and gas exploration and production, road construction and maintenance, and certain other activities, if he finds these are in the interests of the people.

Obviously, few companies will do any prospecting without some assurance that they can extract the minerals which they may or may not find. And if we wait for a national emergency before we open these areas to prospecting, is it likely that we will be able to find the natural resources when we really need them?

We have not made up our minds on the question, but we have some doubts that the bill as drawn would really accomplish the results claimed for it.

MINING IN THE COPPER BASIN

Tennessee Copper Company mines copper, zinc, iron, and sulfur in unusual chemical operation

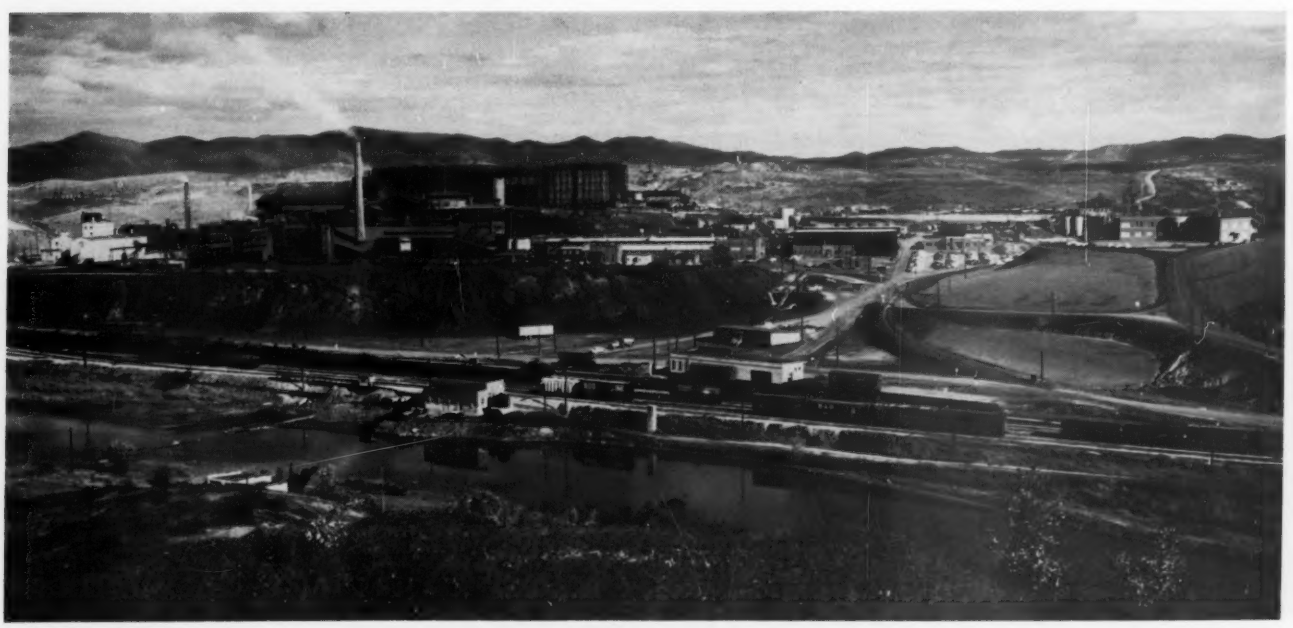
JOHN M. DANTZLER*

At Copperhill, Tennessee, near the tristate corner of Tennessee, Georgia, and North Carolina, is an unusual area known locally as the "Copper Basin," where the Tennessee Copper Company Division of the Tennessee Corporation mines copper, zinc, iron, and sulfur. This district occupies a basin- or bowl-shaped position bounded by mountains reaching an altitude of over 4,200 ft. above sea level, while the basin itself is a dissected plateau at an average altitude of 1,600 ft.

Although the central area is almost completely bare of vegetation, the surrounding land is a paradise of trees, flowers, shrubs, and grass much of the year around. Vegetation in the basin was almost completely obliterated in the fifty-year period prior to 1904. In the early mining operations the copper-bearing ore was roasted in large heaps containing alternate layers of wood and ore. Large quantities of destructive sulfur gases came from the high-sulfur-content ore which, combined with the depletion of timber used for fuel, completely denuded the area.

In 1899, the Tennessee Copper Company entered the basin scene and in six years ended the era of destruction. Later a reforestation program was begun which led to the present program of planting more than 200,000 pine trees each year. Vegetation is gradually coming back, and a chain of lakes on the perimeter of the basin together with a nine-hole golf course provide an ideal playground for residents of the area.

*Hercules Powder Company
Birmingham, Alabama



COPPERHILL PLANT: Tennessee Copper Company's Copperhill Plant is set in the "Copper Basin." The chamber process sulfuric acid plant is in the background at left center, the general office at right, and the Louisville and Nashville Railroad's switchyard in the foreground.

MINE SAFETY ENGINEER: A. D. Annand, mine safety engineer, left, and Mine Superintendent H. F. Kendall stand near the newest mine shaft, the Cherokee. Sinking of this shaft began in 1959, and a drift from the Central shaft to a new ore body on the tenth level began in April, 1958. The connection between the drift and crosscut from the shaft came through on August 23, 1960.

Chemical Analysis

The ore mined consists primarily of the following: pyrite—iron disulfide (FeS_2), or iron pyrites; chalcopyrite—copper, iron sulfide ($CuFeS_2$), or copper pyrites; pyrrhotite sphalerite (Fe_7S_8)—zinc sulfide (ZnS) or zinc blend. The ore bodies formed during the Cambrian Age occur in the Great Smoky Formation. Their dip is from 40° to 70° with thicknesses varying from 10 to 250 ft.

From these ores the Tennessee Copper Company produces copper, copper sulfate, iron sinter, sulfuric acid, fungicides, sodium hydrosulfite, zinc concentrates, and organic chemicals. Practically all the raw materials for this diverse array of products come from the sulfide ore mined in the Copper Basin at the rate of about 1,300,000 tons a year.

Prior to 1925, as the only elements of value recovered from the ore were copper and sulfur, the ore bodies with higher copper content were mined. Later, Tennessee's research efforts perfected processes for separating the iron and zinc minerals, which have made it possible to mine larger ore bodies of lower copper content.

Tennessee Copper Company operates four active mines: the Boyd, Calloway, Mary, and Eureka. A new mine, the Cherokee, is now being developed. The company considers ore reserves adequate for many years, even at the current production rate of 1,300,000 tons a year, which is about a 20% increase over a decade ago.

Operations

Mining operations at Copperhill involve five stages for the production of ore: development; drilling and blasting; loading; hauling; and crushing and hoisting.

Development work is aimed at reaching the ore bodies. The new Cherokee Mine now being developed probably will become an ore producer in about five years. Shaft sinking at Cherokee began in 1959, while a drift from Central shaft to the new ore body on the tenth level started in April, 1958. The crews made the connection between drift and crosscut from the shaft on August 23, 1960. The Cherokee drift is 9½ by 9½ ft. and was drilled with a three-machine hydraulically operated jumbo. Tennessee Copper Company drilled the rounds with three large-diameter (4-in.) burn holes 12 ft. in depth and thirty 1⅝-in.-diameter holes, also 12 ft. deep. Delay electric blasting caps, periods 1 through 10, were used to detonate the 30-hole rounds. This type of cut gave consistently excellent rounds, both in fragmentation and advance in the 5,800-ft. Cherokee drift. Mucking was done with an Eimco 21 loader.

In development and raise blasting, Tennessee Copper Company uses Gelamite® 2, 1¼ by 8-in., and other semigelatin explosives; in stope blasting, Gelamite 2, 1¼ by 16-in., and other brands are used.

The Cherokee shaft is 12½ ft. in diameter, partly concreted and partly gunited. A multiple drill jumbo of company design carries drills for the rounds which are 7 ft. deep. Mucking is done with a Cryderman mucker and advance has been satisfactory. Work on the shaft now is complete to the fourteenth level. This opening will be only a supply and man shaft, while ore production will go up the Central shaft.

Stoping

Tennessee Copper Company does the stope drilling on a fan or radial pattern. The holes are 40 to 70 ft. deep

and spaced so that they bottom approximately 7 to 9 ft. apart. They are drilled parallel to the slot at 3½-ft. intervals from sublevel headings. Tennessee loads the holes with a solid column of Gelamite 2, 1¼ by 16 in., or other explosives, to varying collar depths. An average 75% of footage drilled is loaded. Ensign-Bickford reinforced Primacord* is the detonating agent for each hole, placed so that the initial 3 ft. of explosives will be in contact with the Primacord. The holes are then tied into a reinforced Primacord trunk line and fired instantaneously using one electric blasting cap. The explosives loading ratio is 5 tons for each pound of explosives used.

For stope drilling, Tennessee Copper Company uses Chicago Pneumatic 55 and 65 and Joy HS 15 diamond drills; for development drilling, Ingersoll-Rand DB 35 3½-in. drifters; and for raise drilling, Ingersoll-Rand R 48 stopers. Stope drilling makes use of ⅞-in. Hex. alloy drill steel and 1⅝-in. carbide bits or, in softer areas of the ore, 1½-in. Ex diamond bits. For development drilling, 1¼-in. round lugged steel and 1⅝-in. carbide bits are used; and for raise drilling, 1-in. Hex. carbon steel and 1⅝-in. carbide bits. Tennessee uses carbide bits of 2½-in., 3-in., and 4-in. diameters for burn holes, the large-diameter bits being of the X type rather than the cross type, to minimize rifling. On the average they reset the diamond bits after making 150 ft. of drill hole; the carbide bits average 32 ft. of drill hole before sharpening, and are used eight times before replacement.

*Reg. U.S. Pat. Off.
by The Ensign Bickford Company

Compressor

All compressor stations are on the surface. The main station is located at McPherson and consists of two 2,300-c.f.m. Ingersoll-Rand PRE 2 horizontal two-stage compressors. The auxiliary stations are: Mary Mine—one 1,200-c.f.m. Ingersoll-Rand PRE 2 horizontal two-stage compressor; Eureka Mine—one 2,300-c.f.m. Ingersoll-Rand PRE 2 horizontal two-stage compressor. Also available for shaft work are two 370-

DEVELOPMENT DRILLERS: In the Cherokee drift, drillers position the machines for drilling in the 9½-ft.-high drift. Using a three-machine hydraulically operated jumbo, the two men drill 12-ft. holes, and at the time the picture was taken they were providing for a lay-by to be used for switching mine cars during further advancement of the drift. This site, about 6,000 ft. on the first level, will also be the location of the first raise, permitting entry to the Cherokee Mine ore body above the tenth level.

BOYD MINERS: Two miners are shown here drilling a stope in the Boyd Mine.

c.f.m. Ingersoll-Rand motor compressors. These compressors are in use at the Cherokee shaft. The compressors maintain 95 lb. of air pressure at the drills underground.

Loading

Eimco 21 loaders do the mucking for level development areas and Joy slushers for sublevel development and from stopes. A scram or slusher drift system of scraping ore into chutes from pull holes underneath the stopes loads the ore into cars. Two sizes of Joy-manufactured slushers are used: 25 hp. usually operates from one pull hole, while 125 hp. operates from more than one pull hole. The ore goes into 6-ton, 8-ton, and 10-ton steel mine cars (side dump and rotary dump) for transportation to the crushing stations. Five and a half-ton and 7½-ton Greensburg battery-operated locomotives pull the cars.

The cars dump through feeders into primary jaw-type Birdsboro Buchanan crushers. The crushers are in pockets at strategic levels for each individual hoisting shaft. Ore-hoisting shafts are located at Calloway, Central, and Eureka. Hoisted ore goes through receiving bins into cars at the surface, where a Tennessee Copper Company train hauls it to the mill for further grinding, flotation, and processing.

Crusher sizes are: Eureka—30 by 42 in.; Calloway—42 by 48 in.; Central—48 by 60 in.

Blasting

The explosives loading ratio on headings or drifts is 7 lb. to a cu.yd. in the solid; on stopes it is 0.70 lb. to the cu. yd. of solid. National Mine Service "Permi-Seal" tamping plugs are used to stem all blast holes. Regular delay detonators 1 through 10 in 10- and 12-ft. lengths prime the charges. Blasting takes place at the end of the shift. Magnetic switches of 220 volts at each working level in the mines, initiated by solenoid from the surface, fire the charges. Straight series circuits are used in hooking up all development and raise rounds except shaft rounds, which are wired in parallel.

The method of drilling and blasting used in development and raise work gives excellent breakage and allows for easy loading of the broken material. The method of drilling and blasting used in stoping also gives good breakage, although some secondary blasting is required. For secondary blasting, Tennessee Copper Company employs normal mud-capping procedures during the shift, as boulders may be encountered. Each loading place has a specially constructed shooting station with every possible safety feature to accommodate secondary blasting.

A scram or slusher drift system of scraping ore from pull holes into chutes for loading into cars recovers the material from stopes. Eimco 21 loaders convey the material from heading and raise work directly into mine cars.

The jumbo used to drill the Cherokee drift consisted of three hydraulically operated 8-ft. Joy jibs mounted horizontally. The jibs accommodate a Gardner-Denver CF 99 drill in the center for the cut or burn area. Ingersoll-Rand DB 35 drills mounted on each side of the center drills take care of the remaining holes of the round.

Safety Record

Tennessee Copper makes an exceptional effort to achieve accident-free production. Safety standards for employes of the mining department are printed in booklet form and made available to each employe, and strict adherence to these standards is required. The cooperation of employes in compliance with these standards is excellent. The employes attend weekly safety meetings at their mine and mill locations. The company conducts similar meetings for all supervisors. Safety equipment is the best available. Each employe upon completion of a plantwide 30-day period free from accidents receives an award. Addi-

tional unit awards are made based on the type of exposure and the man-hours of exposure.

The mines have won the coveted Sentinels of Safety trophy five times: in 1933—Burra-Burra Mine (now inactive); in 1942—Boyd Mine; in 1946—Burra-Burra Mine; in 1953—Calloway-Mary Mine; and in 1957—Calloway-Mary Mine.

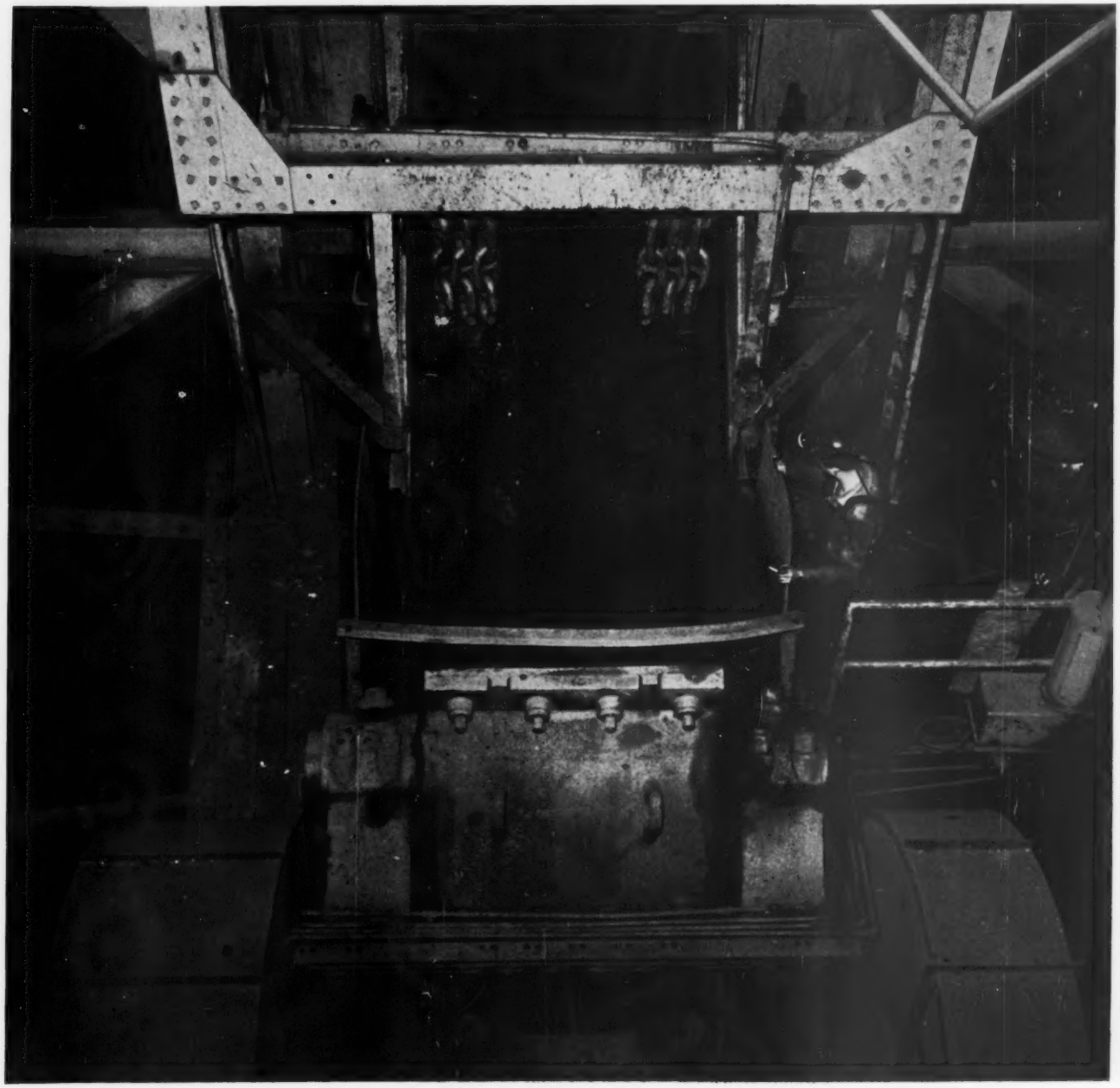
In the period of 1931-1959 the various operations won an additional 21 Certificates of Honorable Mention in the National Safety Competition.

Since 1931 Tennessee Copper Company has won the following additional safety awards: 180 Joseph A. Holmes Safety Association Certificate of Honor Unit Awards; 8 National Safety Council Awards of Honor (highest award of the National Safety Council); and 3 Manufacturing Chemists Associations Awards of Honor.

Personnel

H. F. Kendall is superintendent of the mining department; R. G. Clay, assistant superintendent; D. R. Wagner, chief engineer; S. E. Sharp, director of safety; A. D. Annand, mining safety engineer; Sam Craig, general mine foreman; Harold Dale, Mary Mine foreman; H. B. Estabrooks, Calloway Mine foreman; Gus Nelson, Boyd Mine foreman; Edgar Rose, Eureka Mine foreman; and E. H. Hawkins, shaft-sinking foreman.

T. A. Mitchell is president of Tennessee Copper Company, with offices at Copperhill, Tennessee. R. R. Burns is manager, and Lamar Weaver is general superintendent.



CENTRAL SHAFT: The jaw crusher on the fourteenth level of the Central shaft. After crushing here the ore is hoisted to the surface.

Fundamental Research On Burn-Cut Drift Rounds

Part I of this article discussed the fundamental concepts and related information pertinent to burn-cut drift rounds. This second and final installment covers the experimental process that developed a practical burn-cut drift round, as well as the performance records now being achieved

RICHARD L. BULLOCK*

PART II

EACH year in southeast Missouri, the development drillers of St. Joseph Lead Company drive an average of 10 to 15 miles of drift. It is no wonder then that the Mine Research Department, some five years ago, was given the task of developing a drift round which could be used to give a longer advance per shift than was currently being attained, without putting additional burden on the miner. The objective of the research team was to design a burn-cut drift round which would break 10 to 12 ft. at least 95% of the time. Having once designed a successful drill pattern, the next task to be undertaken would be that of designing a drill jumbo whereby two men could drill out the entire round in a 10 by 12-ft. drift in approximately two to three hours.

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FEDERAL MILL: An important unit in St. Joseph Lead Company's activities in Missouri is the Federal Mill and surface facilities near Flat River. This plant has been in operation since 1906.

Evolving a Successful Burn-Cut Pattern

All of the ideas presented in Part I of this article on "Design of the Experimental Burn Cut" were formulated and tested by drilling and shooting 136 individual tests in the preliminary research of this problem. All the design variables have been discussed at length in Part I; therefore, it seems unnecessary to give a detailed description of all 136 tests. Figure 6 shows the 31 burn-cut patterns that were tried. Table VIII summarizes the results of these tests. They are given in the order in which they were tested and evolved. This table gives the size of the relief holes, the various depths that the cuts were drilled, the number of tests of that particular pattern, and the rated effectiveness of the pattern. This effectiveness is simply the percentage of the drilled depth which broke; i.e., if a cut were drilled 10 ft., but broke only 7 ft., it would be only 70% effective. Many of the early test patterns were very effective for short distances of 4 to 6 ft., but when they were tried at 8 ft. or more, they would fail. Also, when a test pattern was found that would break 8 or 10 ft. consistently in one rock zone, another rock zone was tried. This usually resulted in the cuts' failing to break the full distance.

The patterns in Figure 6, cuts 1 through 11, were chosen to be tested, not on any design features, but rather because they had shown some success of breaking in the Bonneterre formation in earlier years of testing or because the pattern was working in a mine with a rock type that was thought to be similar to our own. From the experience gained in these tests, the remaining patterns were designed and tested. It was not until the pattern shown in cut No. 24 was tested that any real success was achieved. However, this pattern contained three 4-in. holes for relief, and was particularly difficult to drill. The pattern which then evolved and is considered the most successful pattern is cut No. 28. This pattern was tried in several different rock zones and was found completely successful. A few failures occurred while testing some of the variables such as the type of explosive and the firing order. Even by averaging these failures with the tests of the final design, the cut was 92.3% effective. When this cut was tried with the round shown in Figure 7, it broke successfully 96% of the time. Twenty-five 12-ft. rounds were drilled and blasted, and averaged 11.1 ft. of advance per round. The powder factor for the 10 by 11-ft. drifts averaged 14.1 lb. per ft. of advance, or 0.71 tons of rock per lb. of explosive. This is about the same powder factor as shown by the results of the pyramid cut-type drift round in the same size drift.

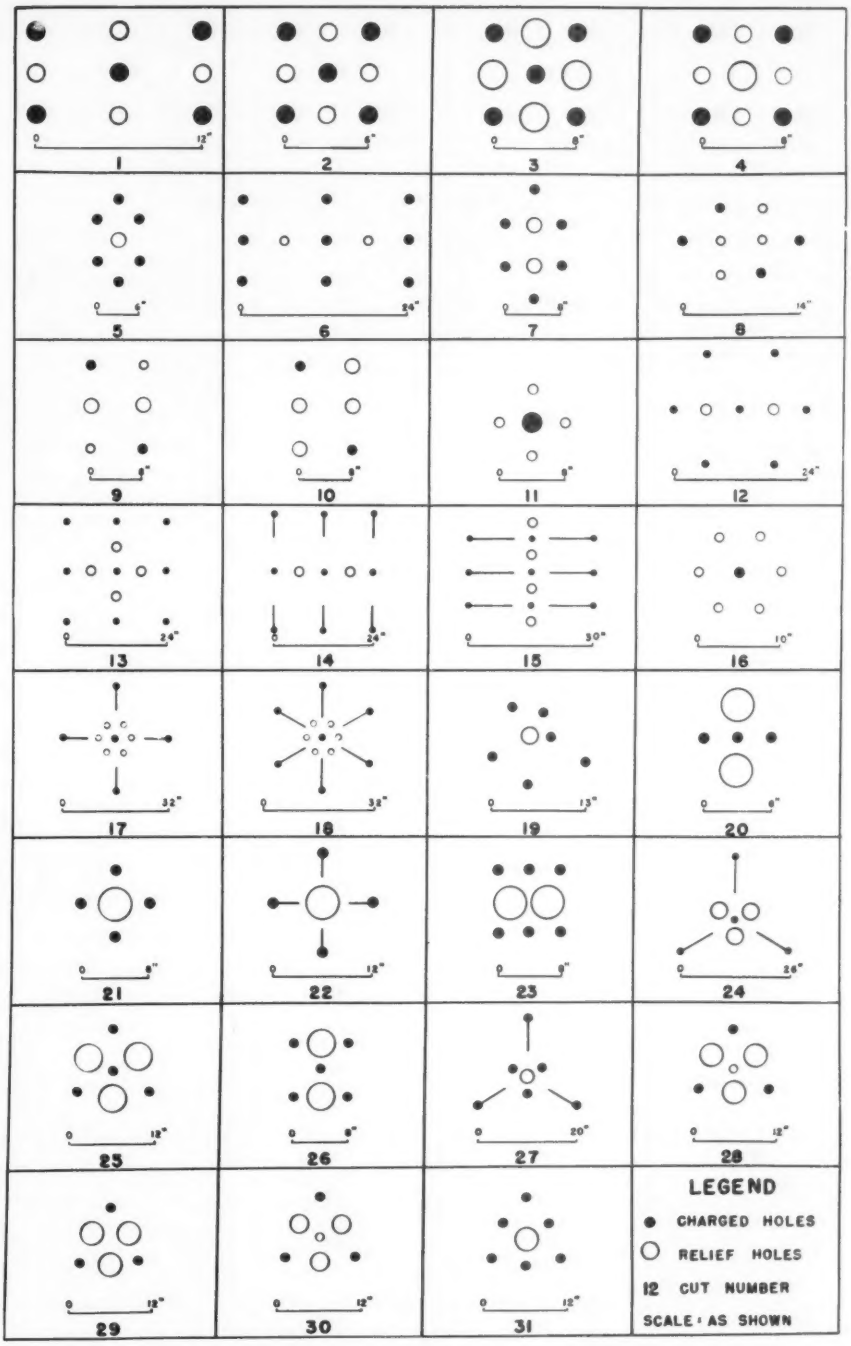


FIGURE 6: During the 136 field trials these 31 various burn-cut patterns were tried in an effort to achieve the most efficient round to meet existing conditions.

The next step was to build a prototype drill jumbo whereby the burn-cut round could be drilled and tested by an operating crew in operating conditions. A three-boom jumbo with remote-controlled feed positioners and

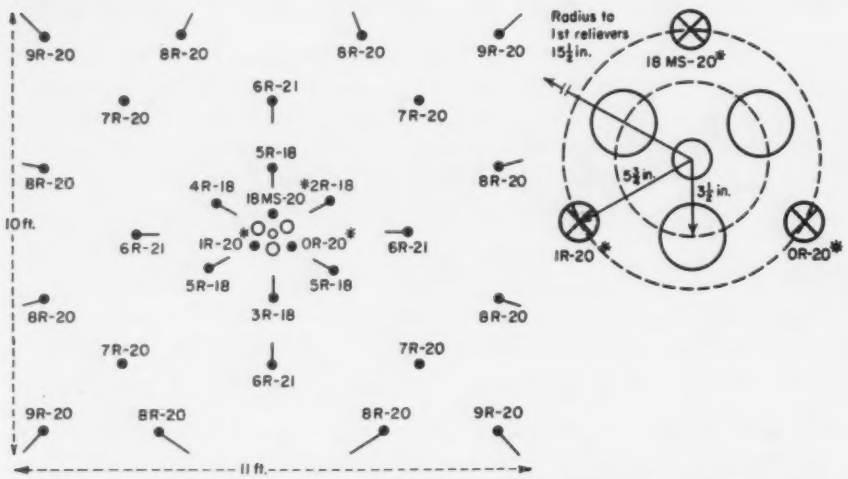


FIGURE 7: An experimental burn-cut drift round which was used by St. Joseph's Research Department to prove its effectiveness. More holes were added to expand it to a larger drift.

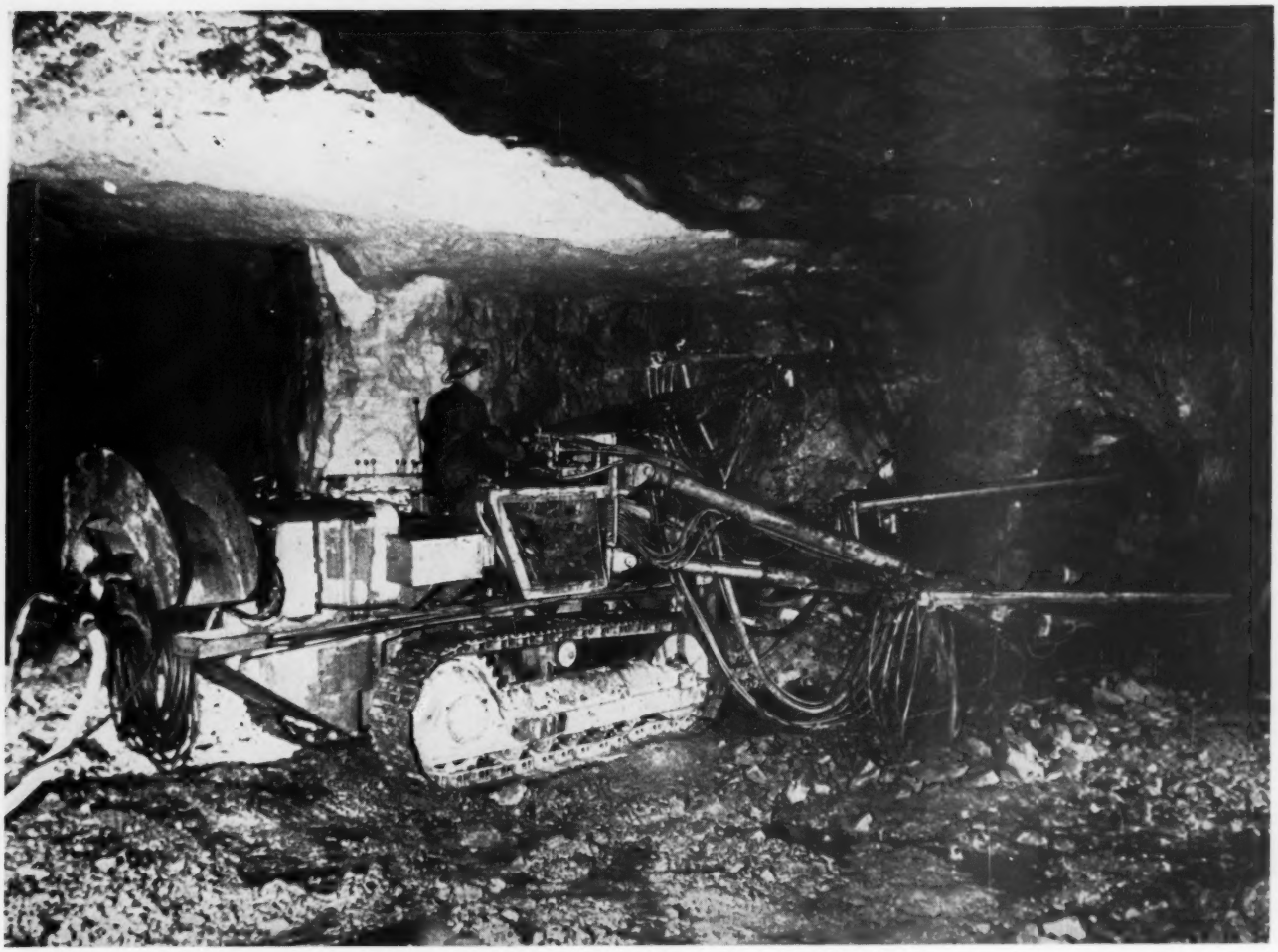
TABLE VIII
Results of Burn-Cut Test Patterns

Cut No.	Size Relief Holes (in.)	Depth Drilled (ft.)	No. of Cuts Tested	Effectiveness %
1	1⅜	4 to 8	5	62.8
2	1⅜	4 to 6	2	63.4
3	2	5.5	1	91.6
4	2	4.0	1	66.7
5	2	8 to 13	8	64.3
6	1¼	8	1	37.5
7	2	8	1	75.0
8	1¼	6	1	50.0
9	1¼ to 2	6	1	66.7
10	1⅜	8	1	25.0
11	1¼	6	1	0
12	2	6 to 8	4	73.4
13	2	8 to 10	17	76.6
14	2	12	1	33.3
15	1⅜	8 to 10	5	69.3
16	1⅜	8	2	50.0
17	1⅜	8	1	62.5
18	1⅜	8 to 10	3	64.3
19	1⅜	8	1	37.5
20	4	8.5	1	75.0
21	4	8.5	2	47.0
22	4	7 to 12	3	60.0
23	4	8.5	1	77.0
24	4	11 to 15	7	98.0
25	4	12 to 15	1	100.0
26	4	12	1	100.0
27	4	10	1	50.0
28	3	12	36	92.3
29	3	11 to 12	4	70.0
30	2½	6 to 7.5	18	90.0
31	3	6	1	84.0

drills was built. This was done by remodeling a two-boom Joy drill-mobile already owned by St. Joe. Because the jumbo chassis was not heavy enough to accommodate long feeds and counterweights, feed length was limited to 9½ ft. The objective was to see what footage could be obtained by a two-man crew cleaning, drilling, and shooting each shift in a 10 by 11-ft. drift. The pattern drilled was the same as that shown in Figure 7. Cleaning the drift was accomplished by using a Joy loader and a Joy shuttle car. The performance achieved was excellent. The crew averaged 8.5 ft. of advance per shift over a seven-week test period and used only 11.5 lb. of powder per ft. of advance. The same crew with column-mounted machines drilling a pyramid cut in the same drift over another seven-week period averaged only 5.9 ft. of advance per shift with 12.7 lb. of powder per ft. of advance.

At this time, the prototype jumbo was moved to the Mine LaMotte mine and tested under rigorous conditions for five months. The round drilled in this mine was basically the same as before, but the pattern was expanded to an 11 by 14-ft. drift. Here the crews averaged 8.1 ft. of advance per shift. The powder factor was 18.4 lb. per ft. of advance, or 0.73 tons per lb. of explosive. Crews in the same mine on column-mounted machines drilling the same size drift with a pyramid-type cut averaged 5.8 ft. of advance per shift and a powder factor of 14.5 lb. per ft. of advance, or 0.93 tons per lb. of explosive.

At this time the economics of the lead industry forced the closing of the Mine LaMotte operation and burn-cut drifting was temporarily halted. However, it was not long after this that the need for a high-speed drifting method would become a paramount problem for St. Joe. This was the opening of the new higher grade lead district at Viburnum, Missouri. On the basis of the research work described, it was obvious that drifting could be accomplished at a much



JUMBO: A three-boom Gardner-Denver jumbo is used to drill burn-cut drift and stope rounds at St. Joseph's Viburnum mines. The jumbo is mounted on a D-4 Caterpillar tractor.

faster rate by using the burn-cut method than by the conventional pyramid cut pattern drilled with column-mounted machines. It was therefore decided that a Gardner-Denver three-boom, tractor-mounted jumbo would be purchased for the initial development of the first mine (No. 27 shaft) in this area. The remainder of this article discusses the drilling and blasting work that has taken place in this mine since that time.

Drilling and Blasting at the Viburnum No. 27 Mine

Rock Type

The ore-bearing rock at the No. 27 mine is in the Bonneterre formation (upper Cambrian age). The Bonneterre is basically a dolomitic limestone which contains various lithologic zones. The ore zone at No. 27 consists of algal reef and oolitic complex formations. The algal reef structures are massive, nonstratified, and consist of small vertical fingerlike columns of algal material with the space between the columns filled with dense gray dolomite. This reef complex is surrounded by bedded, somewhat porous, oolitic dolomite. The oolite beds tend to wedge into the reef from the sides and thus give interbedding of reef and oolite. In the ore zones, both reef and oolite show a considerable amount of nearly vertical tight fracturing. A large portion of these fractures are water-bearing and a considerable amount of water enters the mine.

The "snurly" reef rock is by far the most difficult rock to break. The thick-bedded dolomite breaks somewhat better than the reef rock, though not as well as the thin-layered dolomite beds of the lower portion of the Bonneterre.

Because this rock contains many fractures, it is extremely difficult to drill. Likewise, as pointed out in Part I of this article, any such discontinuities cause the drill rounds to sometimes break short of the desired depth. Also, the fact that each open slip, or fracture, is water-bearing only adds to the complexity of the drilling and blasting problems.

Drill Pattern

Since this mine was laid out for trackless haulage using 10-ton Cline trucks, the development drifts were driven 12 by 24 ft. for the main haulage ways. This necessitated expanding the burn-cut drift round originally developed a second time. More relief and line holes were added, and the

pattern currently being used is shown in Figure 8. The three relief holes are drilled 3 in. in diameter. All the other holes are 1⅝ in. in diameter. The Nos. 1, 2, and 3 holes are charged but not tamped all the way to the collar with 1 by 24-in. cartridges of Hercomite® 7-A (vel. 6,800 f.p.s.). All the other blast holes are charged with 1 by 24-in. cartridges of Gelamite® 1, although if it were not for the extremely wet conditions, Gelamite 2 would be used. Holes 4 through 6 are also charged all the way to the collar and are lightly tamped. The round is drilled an average of 11 ft. deep. It takes approximately 3½ hours to drill the round. The entire round is fired with the P-83 series of Hercules® Electric Blasting Caps.

Drill Jumbos

As was mentioned, a Gardner-Denver three-boom, tractor-mounted jumbo was purchased for the early development work. This jumbo is shown in an accompanying photograph. (In addition to this jumbo, the original experimental prototype jumbo was also sent to No. 27 to start the development.) The Gardner-Denver jumbo consisted of a D-4 Caterpillar tractor which supports three hydraulic-powered remote-controlled booms. Each boom holds a remote-controlled drill positioner, a 12-ft. automatic aluminum screw feed, and an SF79B drifter drill. The two outside booms and drills are controlled by the operator standing behind the control console on the tractors. The center machine is operated by a man on the ground. The center machine drills the cut portion of the round, the first relief holes around the cut, and the two relief holes directly under the cut. The two outside machines drill the remainder of the round in about the same time. The operation of the center boom and machine could be rigged so that it could also be controlled from the operator's console. However, the precise drilling that is required in the burn-cut pattern necessitates the driller's being by his machine.

To render the face completely visible to the driller on the tractor, while all three machines are running, the jumbo is equipped with the following devices:

1. A 9½-kilowatt "defogger" unit[24] that was developed and built by St. Joe to eliminate the exhaust fog of the drills.
2. Two 50-watt Sturdilites mounted on the drill positioners and one 50-watt light on the center boom mounting. These lights are powered by an air motor-driven 24-volt generator.
3. Two New Jersey Dri-Air No. DA-300 water separators placed in parallel on the incoming air line, which help eliminate fog.

The jumbo is extremely flexible in that it can drill a face up to 20 ft. high or as much as 35 ft. wide. Therefore, the same jumbo is used for both drifting and breaking ore in the stopes. In fact, the No. 27 mine is now equipped with four such jumbos and three of them are the ore-breaking units. These units are also drilling the same burn-cut pattern, but more relief and line holes were added to the round to further expand it to the stope conditions.

Drill Steel and Bits

For the most part, Gardner-Denver's 1-in. Hex. carburized steel has been used on the jumbos. For drilling the 1⅝-in. holes, Liddicoat's TSLC single-use Tee Cee bits are being used at the present time. To drill the 3-in. holes, Joy J-40-3 bits are used. In addition, Sandvik Coromant's Integral steel has been used with success on the jumbos. In reality, very little testing has been completed thus far to warrant an opinion on the most economic combination of drill steel and bits on these jumbos.

Loading Units

To clean the drift rounds, as well as the stope rounds, St. Joe shovels[25] are used. They load into 10-ton Cline trucks, which then haul the material direct to the shaft. One shovel operator can keep one truck driver busy operating two trucks interchangeably, i.e., while the shovel is loading the empty truck, the driver is taking the full load to the shaft. This combination can easily load the 200 to 300-ton round in four to six hours.

Also being tested at No. 27 is a Sanford-Day Transloader. The preliminary results of this self-loading self-hauling unit look good.

Performance Achieved at No. 27

Since the mine was first started, about 4 miles of drift have been driven. The crews for the jumbos were

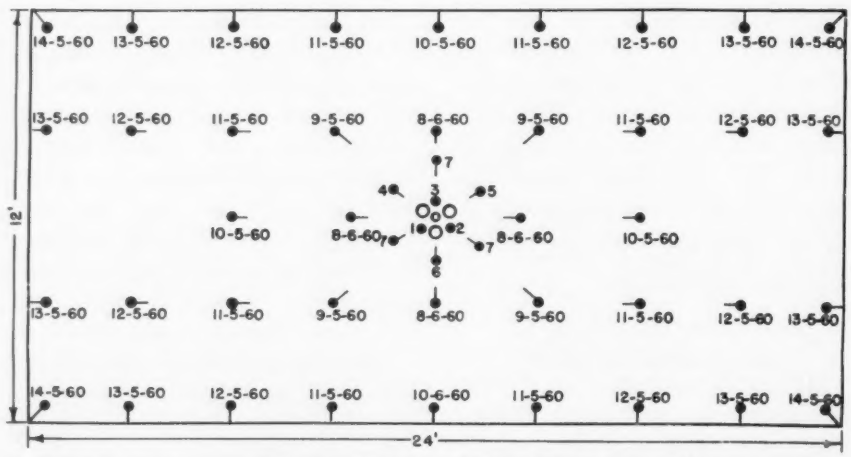


FIGURE 8: The burn-cut drift pattern used for driving drifts large enough to accommodate haulage trucks. The numbers by each hole (i.e. 10-5-60) are codes to indicate loading and firing details. The first number indicates the delay, the second shows the number of 11 by 24-in. cartridges, and the last number the strength of the dynamite. Holes 1 through 7 are charged all the way to the collar but only slightly tamped. Holes 1, 2, and 3 are loaded with Hercomite 7-A. All other holes contained Gelamite 1.

GOOD FRAGMENTATION: As indicated by the well-broken rock, nicely piled for easy handling by the loader, the results obtained with the 12 by 24-ft. rounds are very good.

not picked drillers, but rather they were selected on the basis of seniority-bidding procedures. For the most part they were completely inexperienced to this type of drilling. However, they have steadily improved their average advance per shift since the mine was started. All drillers as well as shovel operators and truck drivers are on incentive contract bonus schedules. Therefore, the work that they perform is greatly influenced by the individual and his abilities. Based on the last two months that No. 27 was in the development stage, four drill crews on two jumbos averaged 9.6 ft. of 12 by 24-ft. drift each, per shift. They broke an average of 242 tons per shift. They averaged 1.04 tons of rock per pound of explosive, or 24.2 lb. per foot of advance. The best crew, taken individually over the same period, averaged 10.4 ft. and broke 262 tons per shift. They averaged 1.11 tons of rock broken per lb. of explosive, or 22.6 lb. per foot of advance. The fragmentation of the rock has been very good.

Since stoping operations have started only recently, reliable performance data are premature. However, it is worth mentioning that the jumbo crews are now averaging about 160 tons per man-shift, with a powder factor of 1.86 tons of rock per lb. of explosive.

While it is felt that St. Joe has developed a more efficient way to advance large drifts and break rock in the new mines, fundamental research on rock breaking has not stopped. In fact, in an effort to stay competitive, rock breaking will always be one of the major items in the company's research program.[26]

The author expresses appreciation to the St. Joseph Lead Company for permission to publish this article.

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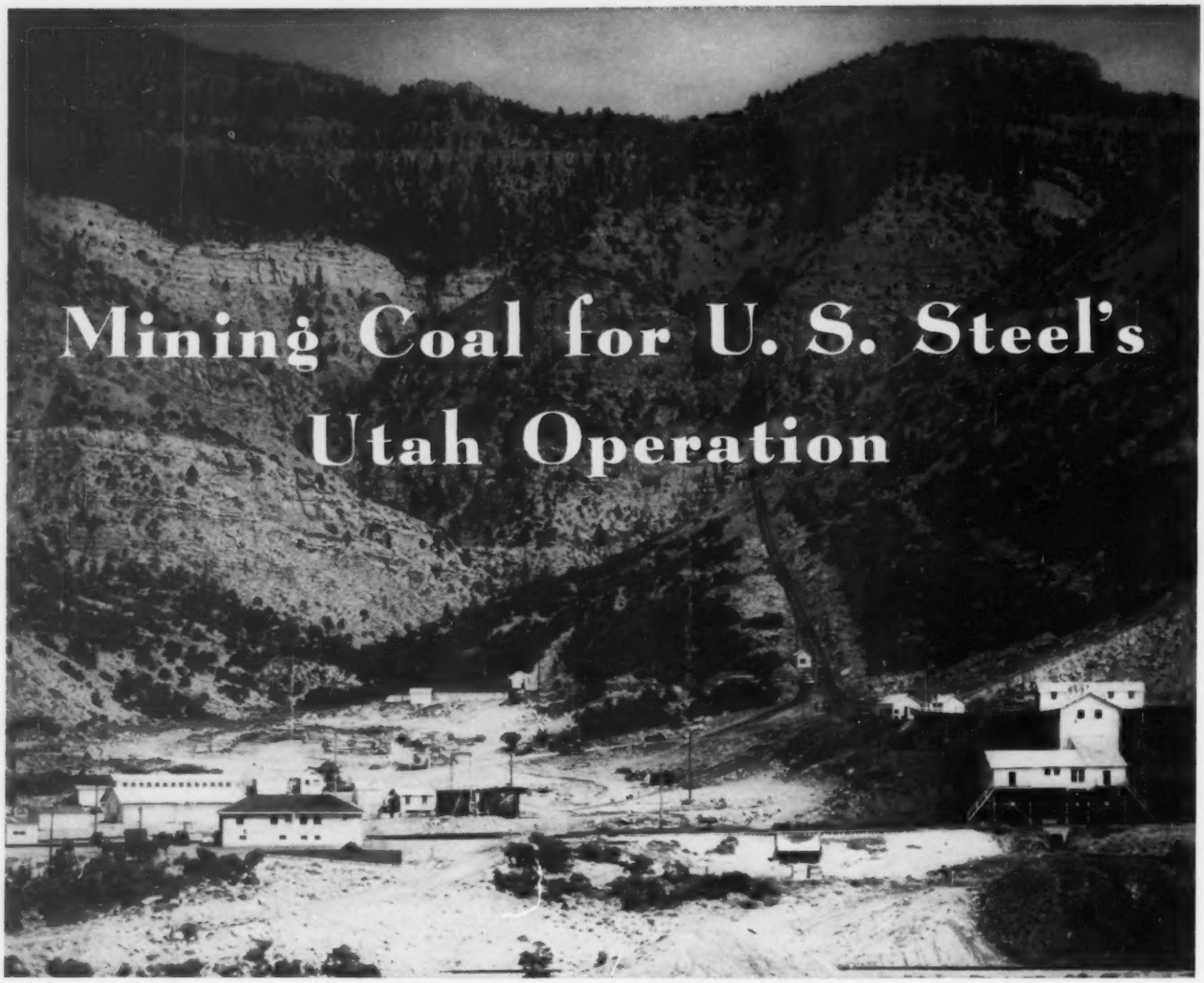
Mining Coal for U. S. Steel's Utah Operation



COLUMBIA MINE: This mine, operated by the Columbia-Geneva Steel Division, supplies part of the coking coal needs of U. S. Steel's western operations. It is located near Columbia, Utah.

The Geneva and Columbia Mines are models of efficient and safe operations; they must be so, in order to meet the coal demands of U. S. Steel's Utah blast furnaces

LEWIS NORDYKE*

ALMOST any time of the year—except the dead of winter when there's apt to be ice on the pavement—the roads that wind through the scenic valleys and the other picturesque rocks and rills of rugged Utah are roaring with the cars of tourists from afar. These folks glimpse many thrilling things, such as the Castle Gate Rock at the entrance of Castle Valley or the craggy bluffs of the Book Cliffs. The touring public pick out picture postcards of some of these breath-taking natural wonders and mail them to relatives and friends who are impatiently suffering it out at home.

This is gorgeous, spectacular country. For example, precipitous cliffs several hundred feet high form the rim of Castle Valley and frown down on it and the Price River. The travelers "Oh!" and "Ah!" at the piles of mountains and the canyon walls with their up-and-down seams of various formations that look a little like the sliced side of a layer cake which has been dropped. Talking in restaurants in such places as Dragerton, Wellington, Price, Orem, Springville, Provo, they wonder how the Mormons managed to get over the often-terrifying terrain to the valley of the Great Salt Lake back in 1847, when there were no highways, railroads, or motels with or without air conditioning. It's a good topic to ponder: the first settlers had to be possessed of courage, fortitude, initiative, stickability, and faith. The fact that

*Deceased

Utah was settled by people of these steel-like attributes makes the state a fascinating one to visit.

But the tourists miss the most exciting modern-day dramas of human endeavor. Maybe they see the neat village of Dragerton, with the general office building for the coal-mining and quarrying operations of the Columbia-Geneva Steel Division, United States Steel Corporation. They probably see the tall coal-cleaning plant at Wellington, the blast furnaces at Ironton, or the integrated steel mill at Geneva Works near Provo. But they don't see the Columbia or the Geneva coal mines or the functioning of the cleaning plant, the blast furnaces, or the glowing open hearths at the steel plant. It seems a shame that tourists can't see what's happening in the very innards of the Book Cliffs. Any man or woman could understand more clearly what it takes to make a piece of steel for car or kitchen if he or she could walk into the mouth of the Geneva Mine, crawl into a mine car, and go back under the mountain 2 or 3 miles where the headlamped men are blasting coal, securing the roof, hauling out the black stuff, and sending it on its long and complicated way to the blast furnace. It takes courage, fortitude, initiative, stickability, and also faith, to mine and gather together the raw materials of Utah and convert them into the steel we use. That's what U. S. Steel is doing.

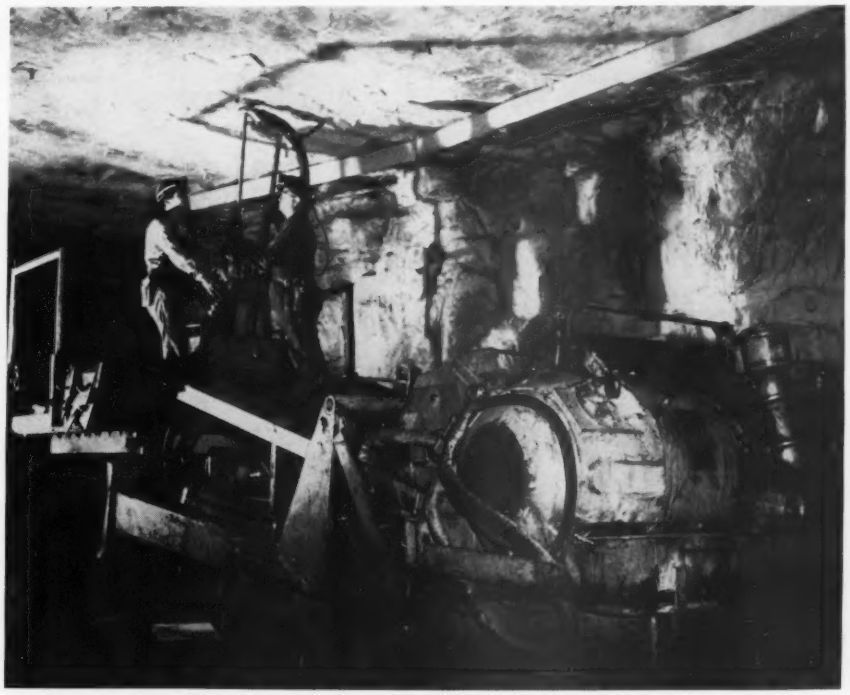
The operation in Utah hasn't been big very long, but it is constantly getting bigger. Columbia Steel Corporation hit Utah in 1924 with a 450-ton blast furnace at Ironton. Coal to make coke came from the Columbia Mine near Dragerton. Columbia's operation was successful. In 1930, when the nation was still reeling from the stock market crash, U. S. Steel, which was certainly not lacking in faith, acquired the Ironton Plant and kept it turning out pig iron.

When World War II started gulping steel, the Defense Plant Corporation opened the Geneva Mine, which is separated from the Columbia Mine only by a 90-ft. fault. With the know-how of U. S. Steel, the Government built a steel plant at Geneva just outside Provo. Coal went to the plant from the Columbia and Geneva Mines, and iron ore from around Cedar City in Iron County some 300 miles south of Salt Lake City. The Geneva plant was an emergency project; ground was broken in March of 1942, a few months after Pearl Harbor; and the first steel was poured in January, 1944. After the war, which was won by efforts that included the step-up in steel production, the plant was closed. But in 1946, U. S. Steel bought the facilities from the War Assets Administration and resumed coal mining and steelmaking.

In 1952, U. S. Steel combined its California and Utah operations into a good-sized division of the corporation. Since that time, Columbia-Geneva Steel has bought the Somerset and Oliver coal properties in Gunnison County, Colorado, as an added source of coking coal; it also has blending coal interests in the Crystal River and Coal Basin areas of Colorado; and it acquires some low-volatile coal from Oklahoma and Arkansas for blending purposes. However, the bulk of the coal comes from the Geneva and Columbia Mines, with Geneva Mine the big producer.

Mining Systems

Both the Columbia and Geneva coal mines use conventional room-and-pillar mining with explosives and also continuous miners. Mining conditions vary district-by-district, with the fault system and the pitch of the seam being the main factors controlling the general layout. The thickness of the rock strata overlying the coal seam is another factor. The cover of the areas now being mined ranges up to 2,500 ft., with an average of more than 1,000 ft. The surface is rugged and sparsely timbered except in the valleys and in some of the cuts and canyons. The mines are in Carbon and Emery Counties on the eastern rim of Castle Valley, which is probably a remnant of a domelike structure, or of a northerly pitching anticline. The center has been eroded, creating the horseshoe-shaped valley 50 miles wide and opening to the south. Many cuts have been eroded into the Book Cliffs. The layers of sandstone and shales that form the Cliffs contain the coal seams, which in the canyons can be seen as plainly as the layer of tasty goo in a jelly roll. The seams slope eastward 12 to 16% downward from the valley's center. Faults radiate from the center of the valley; some of them almost parallel the cliffs. The faults and the dips go deep and affect the mining.



PORTABLE ROOF-BOLTING MACHINE: Designed by mining engineers of the U. S. Steel's Columbia-Geneva Steel Division, this portable roof-bolting machine has proved its worth in protecting workers from cave-ins.

SAFETY MEASURE: Roof bolting is one of the many measures taken to assure the safety of the miners in this modern operation.

The formations containing the coal, which actually is in two seams, are of the Mesa Verde Group, the youngest of the upper Cretaceous age. They are confined to the Blackhawk Formation. The rock stratum consists mainly of sandstone members that vary from a few feet up to more than 50 ft. in thickness. Shales are prevalent, and the sandstone beds are usually interbedded with sandy shales. There are some limestone beds.

The seam being mined is the Lower Sunnyside, which is 14 to 16 ft. thick. It is 6,300 ft. above sea level. The seam is underlaid by massive sandstone that forms a prominent outcrop shelf along the canyon walls. Above the seam are relatively small intermittent sandstone and sandy shale beds averaging about 3 ft. in thickness. And above this is the Upper Sunnyside seam of coal which is 3 ft. thick. It is not being mined at the present.

In general, the old Columbia and the newer Geneva Mines are worked in the same way and the same strict safety programs are followed. U. S. Steel is extremely strong on safety and has been highly successful in guarding against the natural hazards—explosion, fire, gas, dust, caving, and bumps and bounces—of an underground coal mine.

This report is largely on the Geneva Mine, since it is now the more productive of U. S. Steel's Utah operation. The coal seam in Geneva is relatively free from bone or partings except in some of the eastern sections of the mine. Geneva is one mine which produced coal with the start of development. The seam was clearly exposed in the side of the mountain and, therefore, it took no prospecting to find it. When the first round was fired in driving the slope entrance to the mine, coal was produced. Development has followed the seam throughout the mine.

BLAST HOLES: Motorized hydraulic drilling machines make the blast holes in U. S. Steel's Utah coal mines. After the blast the coal is moved from the mine by mechanized equipment and an internal belt system.

Conventional Mining

In the areas of conventional mining, excellent results are obtained with the use of explosives. In driving entries and working rooms, the coal is mined on two shelves. The top shelf of 8 to 9 ft. in height is mined first so the roof can be adequately supported with timbers and bolts. The lower shelf is mined in the retreating operation, when the pillars are pulled, leaving only stumps, which are blasted out to induce caving in the mined-out districts. Very little, if any, of the stump coal is recovered.

The mining face of the top shelf, which is approximately 16 ft. wide, is shot with two rounds of explosives,

LOADING THE BLAST: A workman tamps an explosives charge in the coal face. Hercules Short-Period Delay Electric Blasting Caps detonate the charges, which consist of Red HB permissible explosives.

the bottom holes first and then almost immediately the top holes.

The face is undercut with a cutting machine having a 9-ft. cutting bar. The machine is equipped with an automatic bugdust remover, eliminating the dangerous job of shoveling. Jets of water shoot into the kerf being cut, eliminating most of the dust. The cut is 16 ft. in width. In some instances, the face is sheared; the cutting bar is turned sidewise and makes a perpendicular cut through the center of the face, providing a reliever—another end to shoot to.

Blast holes are drilled with a hydraulically controlled coal auger. The drill is attached to the cutting machine. It can be wormed around to almost any level or angle. Two-inch holes are drilled 8½ ft. deep. They are bored with replaceable bits on 9-ft. steel. The hole is the same size at start and finish. As a rule, five holes are drilled across the bottom. Likewise, there are five holes across the top with holes for three reliever, or cut, shots.

Loading Blast Holes

When the holes are bottomed, each one is loaded with three to four 1¼ by 8-in. cartridges of Red H®B permissible explosive. The first, or primer, cartridge is equipped with a Hercules® Short-Period Delay Electric Blasting Cap. The amount of explosives tamped in the hole after the primer depends on the burden. Each hole is stemmed with clay to the collar. The stemming confines the powder and also guards against the chance of flashes. Both the bottom and top holes are loaded before there is any firing. The charged holes are hooked up in series and fired with a 20-shot permissible blasting machine. Blasting is on shift after the "Fire!" warning has been relayed throughout the district.

Before the holes are blasted, there is an examination for gas and the area is sprinkled with water. From 3½ to 4½ tons of material in the solid is pulled to the pound of explosives. Results of this blasting are highly satisfactory. Secondary blasting is not necessary.

After the blasts are fired, a check is made for methane or other gas. The area is sprinkled and rock dust is scattered. Roof and ribs are examined for loose chunks.

LOADING: Loading the proverbial "sixteen tons" takes but a few minutes with this mechanized loader. Modern mining equipment permits faster and safer coal production than was thought possible just a few years ago.

Loading Coal

A crawler-type loading machine crunches up and sticks its snout into the coal pile. The operator is not exposed to unsupported roof area. The machine loads into shuttle cars of 7-ton capacity. The shuttle cars go rumbling away to unload on a conveyor belt or into mining cars of 8-ton capacity on a rail haulage line.

Then the roof-bolting machine wends its bulky way through the darkness to the freshly cleaned-up face. Holes are drilled and 4 to 8-ft. roof bolts are installed. The bolts are usually on 5-ft. centers. Considerable metal matting—such as that used as emergency airplane landing strips in the Pacific—is bolted to the roof and ribs for additional support. Coal dust is controlled by the application of rock dust (powdered limestone) to all coal-surface areas. There is a minimum of 65% noncombustible content of all dust. An additional minimum of 1% rock dust is added for each 1% methane detected. Only electric power is used in the mines.

When the necessary safety precautions are taken, the blasting procedure continues round after round. The mining of the lower bench is virtually the same—except that the roof has already been bolted. This comes in retreat mining, when the pillars are pulled and the area abandoned.

Conveyor belts which receive coal from shuttle cars unload into mine cars on the main haulage line and the coal is transported to two rotary dump stations on separate levels. The dump stations discharge onto 54-in. belt conveyors, which haul the coal out of the mine and transfer it through a crusher (reduction to a minus 6 in.) to a 48-in. belt conveyor that moves 400 ft. per minute the 3,200 ft. to the tipple, where the coal goes into rail cars.

A third rotary dump from mine haulage to outside conveyor is under construction.

Cleaning Plant

The tipple loads cars on the Carbon County Railroad, which is a USS subsidiary. It runs 11 miles to a junction with the Denver and Rio Grande Railroad, which hauls the cars on to the cleaning plant just outside Wellington.

This multimillion-dollar plant has been in operation only a little more than a year, and is superlative in every

way. Towering 130 ft. into the Utah blue, it is probably the tallest structure in the southeastern region of the state. The all-steel plant uses water to reduce sulfur and refuse from coal destined for steelmaking. The plant is designed to process coal at the rate of 600 tons an hour. Ten miles of railroad tracks inside the 1,500-acre plant area are needed to shuttle coal to and from the facility when it is in full operation. Coal arriving from the Geneva and Columbia Mines, and from Colorado, is dumped into three 600-ton underground bins, each big enough to unload two railroad cars at the same time. The drop-bottom hopper cars are unloaded with a shaking machine to speed the unloading and completely empty the cars.

The coal is blended onto an 800-ft. conveyor belt, which carries it to the top of the building for dumping into four 50-ton bins. These feed raw coal onto four vibrating screens that separate the coarse from the fines. The coarse and fines are washed separately and then finally blended back together after the coarse has been crushed in the cleaning process. After going through the plant, the coal is dried and then loaded on rail cars for the journey to Geneva or Ironton. The process, from the time coal enters the plant until it chutes down into waiting cars, requires only 25 minutes.

Water is drawn from the Price River and from a well into a fresh-water reservoir. Waste water, with refuse, is pumped into a refuse pond. As waste settles out, the water is recaptured and used again. The two reservoirs cover an area equal to 16 city blocks.

In June of 1959, construction started at this site on a drying plant, which went into operation early in 1960. This system is the first such installation west of the Mississippi River. The dryer has a capacity of 800 tons of coal an hour. It improves the quality of the coal, making it more effective for coking. It also minimizes freezing, which sometimes occurs in railroad cars when coal is shipped during winter months. This complete laundry service—washing and drying—adds to the efficiency on up the line.

From the cleaning plant the coal goes by Denver and Rio Grande to the Ironton and Geneva plants.

HAULING: The most modern hauling equipment speeds the coal from the face to the waiting mine cars. The use of this mechanized coal hauler is typical of the modern mining techniques used at this operation.

Growth of Operations

The plant at Ironton has been turning out pig iron since 1924. Ironton has 56 by-product coke ovens and two blast furnaces. This operation is located 10 miles from the Geneva plant. Molten iron from Ironton is transported to Geneva.

The works at Geneva, built during wartime, included by-product coke ovens, three blast furnaces, nine open-hearth furnaces, a 45-in. slabbing-blooming mill, a 132-in. semicontinuous plate mill, a 26-in. structural mill, and other necessary equipment. Since the time U. S. Steel bought the plant, there have been expansions and improvements, including the addition of facilities for producing hot-rolled strip and sheets.

The Geneva plant is on the east shore of Utah Lake, 8 miles northwest of Provo, or some 35 miles south of Salt Lake City. The Denver and Rio Grande runs through the plant area and the Union Pacific runs along the east side. The plant is roughly 600 miles from the Pacific Ocean.

The iron ore is shipped in on the Union Pacific from the open-pit mines at Deseret Mound and Iron Mountain near Cedar City in southwest Utah 250 miles south of the Geneva plant. Columbia Iron Mining Company, a subsidiary of U. S. Steel, operates the mines.

When Cedar City ore is blasted out on 35-ft. benches, it is shoveled into 50-ton trucks which unload at the crushing and screening station. The ore is crushed and screened to 3 to 4 in. It is then hauled in rail cars to Ironton and Geneva.

Mining in Iron County is one of the oldest operations in Utah. Ore deposits were discovered in 1849 and mining started soon after. The first blast furnace was located at Cedar City in 1852. Six years later it was bought and expanded by the Deseret Iron Company, which soon gave up the ghost. There were various other attempts at mining and pig iron production—mainly for the making of stoves, pots, and pans—but there was failure after failure. Utah Steel Corporation was the first to produce open-hearth steel in 1917 at Midvale, a short distance south of Salt Lake City. This operation ceased after World War I, and the production of pig iron also ceased in Utah until 1924, when Columbia Steel finally made a go of it.

Quarrying Operations

Limestone for the open hearths and the blast furnaces is produced at Keigley Quarry, located 28 miles southwest of the Geneva plant. The stone is mined by open-pit methods, with benches of a maximum face height of 35 ft. The benches are drilled and blasted. Three-yard diesel shovels load the material into 24-ton diesel end-dump trucks which haul it a mile to the primary crusher, where the stone is crushed and sized. The pit opened in 1943. It has been developed into 14 working faces.

In the total operation, Columbia-Geneva Steel Division gathers raw material from the various places in Utah and converts it into steel. In every phase of the operation, laboratory tests are made constantly so that blending can be achieved, thereby keeping a constant stream of superior materials running to the plants.

Safety Program

In every phase of the Utah operation safety is of prime concern. It is not the "now be careful" sort of safety but a carefully engineered program. This is especially true at the coal mines, where there are more natural hazards than elsewhere in the operation.

Columbia-Geneva has never experienced a major disaster and has had only one mine fire of consequence. The Columbia and Geneva Mines were the first west of the Mississippi to achieve 100% participation in completion of a Coal Mine Accident Prevention Course conducted under the auspices of the United States Bureau of Mines.

The mines received National Safety Council awards in recognition of outstanding achievements in preventing injuries from roof falls during the national campaign for prevention of injuries from such causes.

Columbia Mine was awarded a Certificate of Honor by the Bureau of Mines for having worked from November 11, 1948, to January 1, 1960, a total of 5,525,030 man-hours without a fa-

END OF THE SHIFT: After the end of their shift, miners ride from the working face to the shower rooms in specially designed man cars which provide safe and convenient transportation.

PREPARATION PLANT: Coal gets the full "laundry cycle"—both washing and drying—at this modern coal-preparation facility near Wellington. From here the coal is shipped by train to Provo, where it is baked into coke.

tality. This record has now been boosted to nearly 6,000,000 man-hours. The national average for bituminous-coal mines is 0.64 fatalities for each million man-hours of exposure.

Geneva Mine was awarded a similar certificate for having worked from April 28, 1955, to January 1, 1959, a total of 3,318,830 man-hours without a fatality.

The Mine Inspection Department is charged with the staff responsibility of defining and administering the safety, casualty, and inspection program. Three basic principles of prime importance in the structure of the safety program have been laid down by the department as:

1. Safety is a supervisory function. Safety and operating practices are interrelated and cannot be separated.

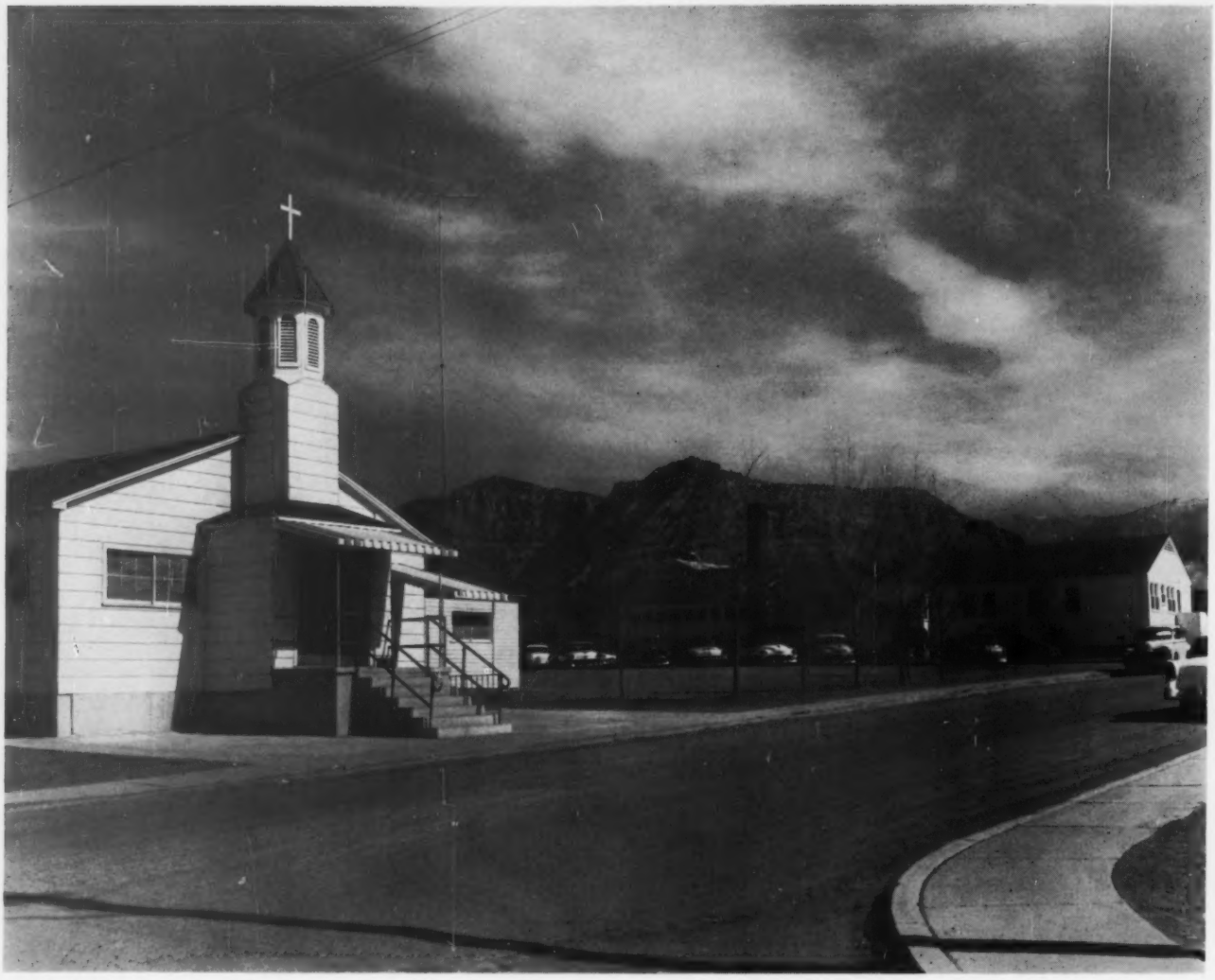
2. To prevent injuries and fatalities it is necessary to first stop the cause. If the cause does not exist, no injury can result.

3. Conservation of life and property is a profitable combination and good business.

The coal mines are well ventilated. Safety gates, shields, and guards are used on locomotives and other mobile equipment. Emphasis is pin-pointed on guarding against human error. And a great deal of attention is directed at equipment safeguards, mining technique, gas detection, explosion, fire, bump-and-bounce hazards. All personnel is kept injury-conscious. Specific problems are discussed at weekly safety meetings. Employe suggestions are welcome. The mines have a thorough first-aid program. Every year, Columbia-Geneva cooperates with the Bureau of Mines in offering an intensive 15-hour course in first aid. Twice in recent years these mines have been the Utah State First Aid Champions.

Aid stations, with full equipment—fire-fighting, gas masks, oxygen supply, a mine ambulance—are located in the mines and especially near the working faces. Ventilation is checked carefully, the quality of the air being measured by safety lamps for the detection of methane or oxygen deficiency. In the Geneva Mine, 600,000 cu. ft. of air per minute is circulated by three heavy-duty fans. Circulation is controlled by walls erected to separate the intake and return airways. In working districts, the flow of air is directed by heavy brattice curtains.

Of course, the use of rock dust neu-



DRAGERTON, UTAH: This attractive village serves as a residential as well as an operational headquarters for many of those engaged in the vast coal-mining activities carried on in central Utah.

tralizes to a great extent the coal dust. Water is also used freely to keep down the dust.

Bumps and Bounces

Perhaps the major hazard in these mines is the danger of bumps and bounces, especially in the retreat operation when the pillars are pulled and the lower bench of the seam is mined. The mines in this area, which are generally known as the Carbon-Emery coal fields, have had long experience with the bounce problem. Bounces—an outburst of coal caused by extreme weight pressure, or pressure shifting, in a particular place—are not confined exclusively to pillar work but can occur in development in virgin coal. A bounce may range from a simple coal outburst in a face area to widespread damage. This has long been a major hazard in the industry. Much work has been done on it, but the total elimination of the bounce is not in sight. The use of roof bolts, bench mining, and other modifications developed by Columbia-Geneva Steel has resulted in a reduction of frequency and severity of injuries from bounces.

One of the most successful methods of inducing bounces has been the drilling of long holes, up to 20 ft., into a pillar with standard drilling equipment and shooting light charges of explosives. However, this method induces bounces only in the particular area and does not assure that other bounces will not occur elsewhere.

The progress made in coal mining safety in recent years, and especially by U. S. Steel, indicates that one day out in the future man will engineer a method that will eliminate the danger of bumps and bounces in underground coal mining.

The Columbia-Geneva Steel Division is an excellent housekeeper. The surface area—containing the mine office, warehouses, machine and repair shops, change rooms, and other installations—is as prim as you please. The attractive, air-conditioned administration building for mines and quarries is located at Dragerton, a town that came to life in a hurry when wartime operations brought the opening of the Geneva Mine. Dragerton is a neat town. Employe housing was constructed by the Government during wartime. When U. S. Steel bought the operation, the houses were sold to employes. There is no company town.

American-Marietta Wins Explosives Engineer Plaque

Greatest number of awards made for injury-free year since NCSA contest began

THE National Crushed Stone Association's 44th annual convention at the Americana, Miami Beach, Florida, celebrated an outstanding safety year by its members when 59 of the 134 participants in the association's safety contest received awards for operating throughout 1959 without a disabling work injury. This was the greatest number of such awards since the contest began in 1926.

The 1959 contest also achieved distinction by recording the greatest number of participants and the highest number of man-hours of exposure to hazard for any year in the history of the contest.

The Kimballton Mine, Kimballton, Virginia, of the Standard Lime and Cement Company, division of American-Marietta Company, won THE EXPLOSIVES ENGINEER plaque for operating the greatest number of consecutive days without a disabling work injury, running up a total of 2,663 days to December 31, 1959, without an injury.

Designed to stimulate interest in the accident-prevention programs through the recognition of plants working throughout the year without disabling injuries, the safety contest is conducted by the United States Bureau of Mines of the Department of the Interior. Statistics obtained by the Bureau from the quarries and mines of the association provide the basis for the awards to the winning operations.

The National Crushed Stone Association contest was divided into five man-hour groups to provide greater incentive for the smaller operations: Group I, plants working 201,000 man-hours or more; Group II, 100,001 to 200,000 man-hours; Group III, 50,001 to 100,000 man-hours; Group IV, 30,001 to 50,000 man-hours; and Group V, 30,000 man-hours or less.

Group Winners

The winner in Group I, the largest group, was the Port Inland Quarry, Gulliver, Michigan, of the Inland Lime and Stone Company, division of Inland Steel Company, which operated 451,317 man-hours without a disabling work injury. A. J. Cayia, Jr., is superintendent of the quarry.

The winning quarry of Group II was the Dan Quarry, Martinez, Georgia,

LONG RUN: Run of 2,663 days without a disabling work injury won "The Explosives Engineer" National Crushed Stone Award for the Kimballton Mine of the Standard Lime and Cement Division of American-Marietta Company. James Westfield, assistant director, Health and Safety, United States Bureau of Mines, left, presents the plaque to G. C. Larkin, superintendent.

operated by Superior Stone Company. This quarry operated 177,333 man-hours without a disabling injury. R. Y. Shuping is superintendent. The Kimballton Mine also placed second in this group with 176,581 man-hours.

McLeansville Quarry, McLeansville, North Carolina, of the Superior Stone Company, was the winner of Group III, with 99,900 man-hours without a disabling injury. P. M. Williams is superintendent.

The Group IV winning quarry was the Knoxville City Quarry of the Lambert Brothers Division of Vulcan Materials Company, recording 46,621 man-hours without a disabling injury. Lawson Tice is superintendent.

The Group V winner was also a Lambert Division operation, the Franklin Mine, Franklin, Tennessee, working 28,736 man-hours without a disabling injury. J. R. Webb is superintendent.

The Awards

The plant with the greatest number of man-hours worked without a disabling work injury in each group receives a wooden plaque with a bar inscribed "Group Winner," the number of man-hours worked, and the year in which the record was made. For each additional year up to five without a disabling work injury, the plant will receive a bronze bar similarly inscribed; from five to ten consecutive years, a silver bar; and for ten or more consecutive years, a gold bar. Each employe of these operations receives an individual certificate inscribed with his name.

Safety Record Improved

The experience of the quarries entered in the 1959 contest was considerably improved over the preceding year. Although four fatalities occurred, compared with eight in 1958, the injury-severity rate of 3,436 days lost per million man-hours was only slightly over half that of the 6,360 rate for 1958. The injury-frequency rate of 18 injuries per million man-hours was also lower than the 21 injuries for 1958.

The competing companies experienced 220 disabling work injuries, of which four were fatal, 11 permanent total disabilities, and 205 temporary total disabilities. These 220 injuries resulted in 186 days' lost time per injury, a marked improvement over the 296 days lost for each injury in 1958, but which was still above the 34-year average of 182 days lost for each injury.

Classification of Injuries

Injuries in 1959 were classified as follows: haulage caused two fatalities and one permanent partial injury; falls of persons, one permanent partial injury; falling objects, one permanent partial injury; flying objects, two permanent partial injuries; drilling, one permanent partial injury; machinery, two fatalities and four permanent partial injuries; and one permanent partial injury from other causes. The accompanying table shows the days of disability by classification of injuries in the 1959 contest.

Of the operations enrolled in the contest, 117 were open quarries and 17 were underground mines, the greatest number of mines ever entered in the contest. Fifty-nine operations enrolled in the contest, and two additional enrolled for statistical purposes only, worked 4,819,147 injury-free man-hours, or 41% of the total of the 134 operations in the contest.

Twenty-two states were represented in the contest, as follows: 21 in New York; 13 in Kentucky; 12 in Ohio; 11 each in Pennsylvania and Tennessee; 8 in North Carolina; 7 each in Illinois, Missouri, and Virginia; and 6 in New Jersey; 4 each in Georgia, South Carolina, and Wisconsin; 3 each in Connecticut, Iowa, and Maryland; 2 each in Indiana, Massachusetts, Michigan, and Texas; and 1 each in Montana and Oklahoma.

Classification	Fatal	Permanent		Temporary	Total
		Total	Partial		
Falls and slides of rock	—	—	—	26	26
Handling materials	—	—	—	408	408
Hand tools	—	—	—	172	172
Explosives	—	—	—	151	151
Haulage	12,000	—	120	931	13,051
Falls of persons	—	—	600	2,591	3,191
Bumping against objects	—	—	—	102	102
Falling objects	—	—	240	323	563
Flying objects	—	—	3,600	70	3,670
Electricity	—	—	—	10	10
Drilling	—	—	75	151	226
Machinery	12,000	—	5,260	563	17,823
Stepping on objects	—	—	—	164	164
Burns	—	—	—	62	62
Other causes	—	—	150	13	163
Total	24,000	—	10,045	5,737	39,782
Not stated	—	—	—	1,053	1,053
Grand total	24,000	—	10,045	6,790	40,835

T. E. CONNOLLY

GEORGE T. McCOY

THE BEAVERS AWARDS

Western construction organizations honor four men for outstanding achievement

At the annual Beavers Awards' banquet held on January 19 at the Biltmore Bowl in Los Angeles four prominent leaders in the West's heavy-engineering-construction industry received the 1961 Golden Beaver Awards in recognition of their outstanding careers. The presentations were made by Paul Grafe, president of the Beavers, the association of dam builders, heavy constructors, and suppliers whose members have served on almost every major construction job west of the Mississippi during the twentieth century.

Recipients of the coveted Golden Beavers for 1961, and their fields of activity, are listed below:

DAVID E. ROOT

MANAGEMENT: T. E. Connolly, president, T. E. Connolly, Inc., and Connolly Pacific Company.

SUPERVISION: David E. Root, vice president (retired), Guy F. Atkinson Company.

ENGINEERING: George T. McCoy, chief (retired), California Division of Highways.

SPECIAL: John L. Savage, Consultant.

JOHN L. SAVAGE

The Luck of the Irish

CHARLES F. THOMAS*

THE Shamrock Bar was a saloon of the early days of the wild and woolly mining camp of Leadville, Colorado. Its proprietor, Pat McGuire, had tried his luck at mining but always had dreams of an easier way of earning a living. When a two-day high-stakes poker session ended with Pat holding most of the money contributed to the game, he used his winnings to erect a building on a lot in Leadville, stocked it with liquor, and opened his saloon. He chose Ireland's shamrock as the name of his saloon and a name most likely to bring him luck.

Costs of all kinds of merchandise were high because of the long freight haul from Denver with oxen and mules, and selling prices were established in multiples of the "two-bit," or 25-cent, piece. So it was little wonder that neither Pat nor any of his bartenders would keep a coin less than two bits in his tills. If 20-cent pieces, half dimes, or any of the numerous penny or half-penny pieces were laid upon the bar in payment for a shot of whiskey or a cigar, the goods were supplied but the money was tossed to the top of the big walk-in icebox in which Pat stored his kegs of beer, champagne, and supplies for his popular Dutch lunch. Life was busier on the streets and in the saloons and dance halls at night than in the daytime. Poker games lasted days at a time and service for thirsty patrons had to be provided. The Shamrock operated 24 hours a day.

Pat prospered from the beginning. He courted and married an attractive Irish colleen who had come out from New York City to teach school. After a few years he remodeled the bar and placed a large plate glass mirror behind it. He also purchased and hung on the wall the famous painting, "The Reclining Nude." And through the years he continued to toss the small coins to the top of the icebox.

During one of the severe winter storms in Leadville in the late '90's Pat McGuire dropped dead while shoveling snow from the sidewalk of his home. In true Irish fashion his sudden passing was suitably mourned at a neighborhood wake. Hundreds of friends and acquaintances mourned his passing and he was honored with one of the largest funerals ever held in Leadville.

Katie McGuire, his widow, soon decided to sell The Shamrock and return to New York. Jimmy Kelly, newly arrived from Denver and seeking a going business, offered Mrs. McGuire an attractive price for the saloon. She accepted his offer and deeded to him the lot, building, fixtures, and good will—and even the painting which she had always criticized Pat for purchasing and displaying.

The new owner planned a few alterations, improvements in keeping with the changing times. One of the most important changes planned was to replace the old icebox with a modern fixture. Investigating the construction of the old box, he obtained a ladder and clambered to its top, close under the ceiling of the barroom. There he discovered the pile of coins which had been accumulating slowly through the years. They were greasy and dirty and not too easily identified.

Jimmy took a shovel and one of the heavy coal hods used to fire the big stove and loaded it with gummy coins. He lugged it down the ladder, dumped the money on the floor, and went back for more. In all, he carried down 11 buckets of coins. Cleaning the coins was a tedious job and attempting to estimate the worth of his find was a real problem. The local bank manager realized the possibility that many of the old coins would be of value to collectors and suggested to Jimmy that he sort and sack the coins and store them in the vault of the bank while their worth was determined. After days of washing, sorting, counting, and sacking, the money was loaded in a borrowed wheelbarrow and carted to the bank.

How much was obtained from the pile of discarded money was never revealed. A gossipy bank clerk declared that in the face value alone there was more than $2,000. Word traveled rapidly concerning Kelly's "strike" and offers to purchase rare coins came from numismatists all over the country. It was rumored that Jimmy sold some coins for as much as the entire pile totaled.

When some good friend wrote to Katie McGuire and told her of the discovery of the discarded coins, it is reported she said, philosophically, "Well, an' faith! It could all be the good will I sold him!"

*5602 Long Beach Boulevard
Long Beach, California

NEWS NOTES

PIPELAYER BROCHURE

A handy reference booklet describing Cat-built pipelayers, from the big 583 to the D4C Tractor with pipelayer attachment, has just been released by Caterpillar Tractor Co.

Titled "Caterpillar Pipeline Equipment," the 8-page booklet shows action and model views of Caterpillar's line of five pipelayers and gives brief specifications of each. The brochure also describes power-matched welding units, clearing and ripping equipment available to pipeliners for Cat-built tractors.

Copies of this bulletin may be obtained by writing to the Advertising Division, Caterpillar Tractor Co., Peoria, Illinois, and requesting Form D104.

BACKHOE BULLETIN

The Parsons-Shawnee 1500 backhoe is the subject of a free new bulletin obtainable from the Parsons Co., Newton, Iowa, manufacturer of trenching machines and utility tractor attachments.

This four-page bulletin illustrates and describes the backhoe's many exclusive features and cylinders, pistons, and hoses. Also includes complete specifications on the backhoe attachment and various size buckets.

GENERATOR BULLETIN

A new high-capacity series of Winco Engine Generators is announced by Wincharger Corporation. The new "91" Series engine generators are specially designed to provide standby electric power in the event of power line failure.

According to the manufacturer, the new "91" Series offers the proven advantages of Winco's exclusive Maxi-Watt Power Control, which provides maximum power for heavy motor loads, or maximum efficiency for light and normal loads. The "91" produces 9,000 watts of AC intermittent-duty power, or 7,500 watts of continuous power. Complete information, specifications, and prices will be sent upon request to Wincharger Corporation, Sioux City 2, Iowa.

ELECTRICAL CODE BULLETIN

Crouse-Hinds condulets and the National Electrical Code are discussed in Bulletin 2722, a 60-page publication detailing the applications of condulets in hazardous locations. Code Articles 500-503 and 510-517 are quoted, along with Crouse-Hinds recommendations for condulets meeting the various code requirements.

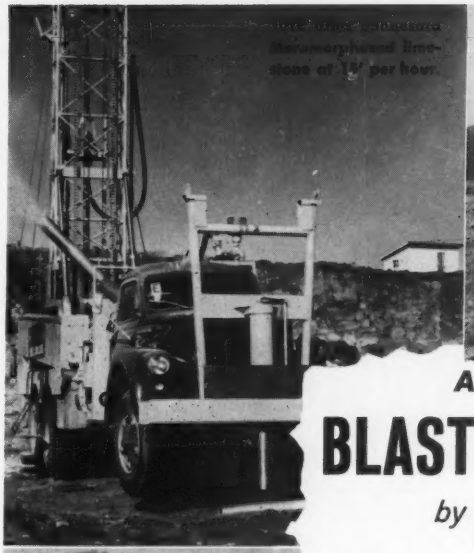
More than 300 product photos, installation photographs, and drawings illustrate this informative bulletin. A valuable reference for planning electrical installations in any and all hazardous locations, Bulletin 2722 is available on request from Crouse-Hinds Company, Syracuse 1, New York.

CHEMISTRY-GEOLOGY COURSE

A six weeks' institute in chemistry and geology for high-ability secondary students will be held at the Colorado School of Mines this summer. The institute, scheduled for July 10 through August 18, will be supported by a $13,985 grant from the National Science Foundation.

Announcement of the unique chemistry-geology high-school program was made today by Dr. John W. Vanderwilt, president of the mineral engineering college.

Some 50 high-school students, most of them to be seniors next year, will be accepted on the basis of academic ability and potential. They will be quartered at the college's dormitories, and each student will be required to pay half of his travel expenses and subsistence while studying. The NSF pays the remainder of each student's cost plus the instructional expenses.



Truck mounted 6TA drills blast holes for coal operations.

AIR ROTARY

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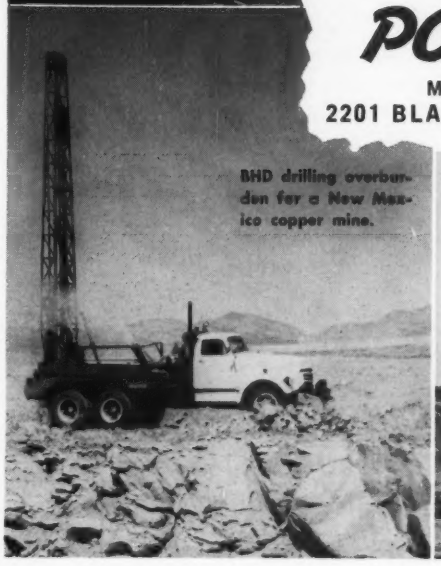
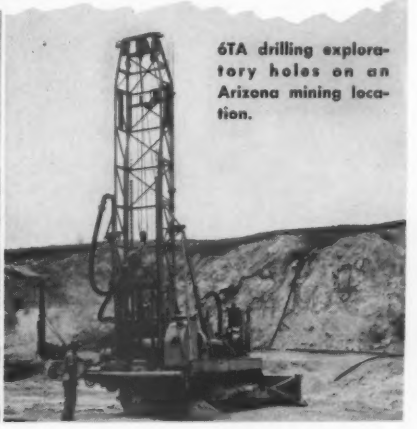
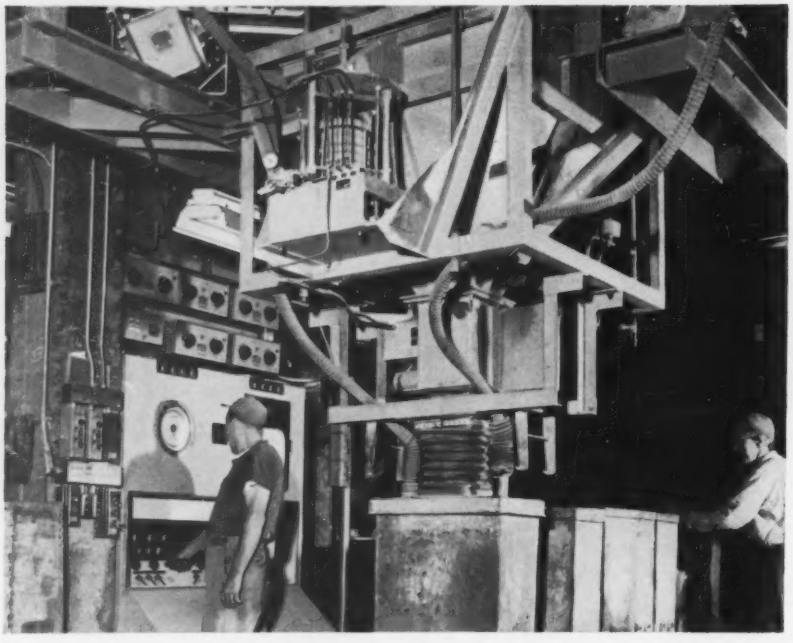

BHD drilling overburden for a New Mexico copper mine.


6TA drilling exploratory holes on an Arizona mining location.

AT CARBORUNDUM...



Accuracy and Instantaneous Control Response with W & C BATCH-WEIGHING SYSTEMS

Critical formulation standards are maintained at lower cost since Carborundum Company has introduced automatic batching of ingredients at their Perth Amboy, N. J. refractories manufacturing plant. The new automatic system—designed with W & C pre-engineered and laboratory-tested "building block" components—has greatly increased production, reduced labor costs, and decidedly improved the accuracy of batch weight control.

Chief reason for the accuracy of W & C Batch-Weighing Systems is the patented Uniforce flexural frame used in supporting both weigh-hoppers and weight transmitters. These unique flexural frames ensure accurate weighing under *all* load conditions, resolve *every* force and moment into a single vertical component applied to the load transducer.

Immediate response to control material flow in *any* batching operation is provided by the W & C Pneumatic Weight Transmitter, a force-balance instrument delivering a highly reproducible, (1 part in 2000) almost *instantaneous* signal directly proportional to net weight. No possibility of overshooting specified ingredient quantities. Practically no maintenance, compared with mechanical systems. The W & C scale is dynamically faster than a beam-and-balance or flexural beam system . . . W & C uses air, has no inertial mass to overcome . . . comes into balance sooner than a mechanical system.

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WRITE FOR BULLETINS / Bulletin 30 fully describes W & C Batch-Weighing Systems
Bulletin 14 describes other W & C Automatic Weighing Systems

WC 100

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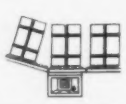
CONSTANT-FEED WEIGH-HOPPER SYSTEMS


CHECK-WEIGHING SYSTEMS

CONTROL PANELS

See page 644 Chemical Engineering Catalog for list of representatives

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Phone: Lakeview 4-0028

Prevent!

DYNAMITE BLAST VIBRATION

- DAMAGE
- COMPLAINTS, DELAYS
- UNJUST LAW SUITS, LOSSES

with your own

BLASTCORDER

- Designed especially for dynamiters.
- Even a housewife can understand the vibration reading on the meter. Meter helps blaster keep shots safe. Makes impressive demonstration indoors and outdoors to maintain good community relations.
- Pushing 2 buttons makes an immediate 4 x 5 record scaled like the meter — no photo processing, no delays, no computations. Helps satisfy complaints on the spot and prevent law suits. Invaluable permanent record for evidence.
- Rugged for field use. Weighs 20 pounds with batteries. Dimensions: 6 x 12 x 19 inches.
- Price: 1-component model $1225, 3-component model $1800. Records 30 cents each.

GEOTECH
The Geotechnical Corporation
3401 Shiloh Road, Garland, Texas
Phone BR 8-8102

New Joy TDM-B1 swing boom trac-drill has complete power positioning and automatic hose reel

The new Joy TDM-B1 Trac-Drill with swing boom features full range power positioning of the drill. In swinging to any drilling angle from vertical to horizontal, there are no manual adjustments. The exclusive new hose reel trains air hose in all drilling positions, eliminating fouling—saving frayed hose and tempers.

Another exclusive feature, a new control arm swings the drilling controls with the boom. It puts the operator up front, where visibility for spotting is best, and then can be moved to any desired position—operation is independent of the boom.

The TDM-B1 carries Joy's dependable 450-DR Dual Rotation Drill. This drill provides hammer-free rotation for fast steel changes, plus a strong assist to normal rifle-bar rotation when needed.

The Joy TDM carrier is the most versatile machine in its class, and now offers you the option of either the new Swing Boom model, or the universal U-Bar machine. For complete information on the Joy TDM Trac-Drill, see your Joy distributor or write for Bulletin 2671-5.

JOY CONSTRUCTION EQUIPMENT IS SOLD AND SERVICED BY THE JOY DISTRIBUTOR IN YOUR AREA

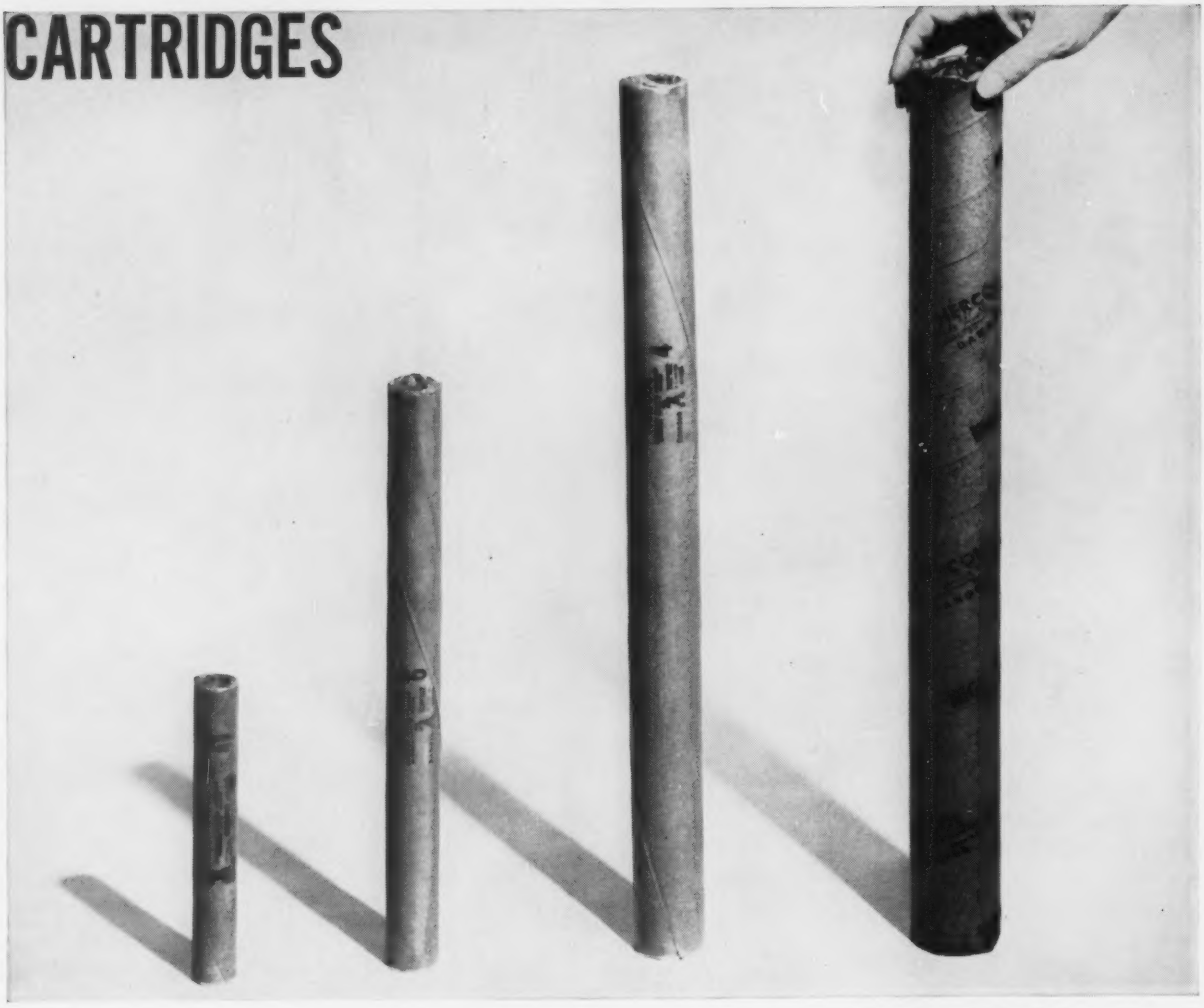
JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Portable Compressors	Trac Drills	Tungsten Carbide Rock Bits	Hand-Held Rock Drills

HERCOL®—A LOW-COST EXPLOSIVE—NOW AVAILABLE IN SMALL-DIAMETER CARTRIDGES



The Hercol series of low-cost, cap-sensitive, high-ammonia-content explosives are now available in cartridges of small diameters and standard lengths, as well as in the larger diameters and special packings.

The ability of Hercol to produce excellent fragmentation, its water resistance, Class 1 fumes, and high cartridge count—plus its low cost—have already been proved to the economy-minded quarry and open-pit operator.

Now that Hercol is manufactured in the smaller diameters, with Class 1 fumes, these same economies are available to the underground operator.

Contact the Hercules sales office nearest you or ask your Hercules representative for more detailed information on how Hercol can reduce blasting costs for you, too.

Properties of Hercol

	Hercol	Hercol 2	Hercol 4	Hercol 6
Fumes	Good	Good	Good	Good
Cartridge count—1¼ by 8-in. cartridges per 50 lb.	130	120	140	165
Cartridge diameter, in.	4 to 8½	1 to 3½	1 to 3½	1 to 3½
Weight strength, %	70	68	68	68
Cartridge strength, %	48	50	34	19
Water resistance	Fair	Good	Fair	Fair

A special grade of Hercol is formulated for seismic "pattern shooting" when the drill-holes are relatively dry.

Explosives Department

HERCULES POWDER COMPANY

INCORPORATED

Hercules Tower, 910 Market Street, Wilmington 99, Delaware

XR60-1

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